2022-2091, -2115

United States Court of Appeals for the Federal Circuit

KOSS CORPORATION,

Appellant,

– v. –

KATHERINE K. VIDAL, Under Secretary of Commerce for Intellectual Property and Director of the United States Patent and Trademark Office,

Intervenor.

Appeals from the United States Patent and Trademark Office, Patent Trial and Appeal Board in Nos. IPR2021-00305 and IPR2021-00381

JOINT APPENDIX

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Koss Corp. v. Vidal
2022-2091 (IPR2021-00305)
Consolidated with 2022-2115 (IPR2021-00381)

Appendix Table of Contents

Filing Date	Exhibit/ Paper No.	Document Name	Availability	Appx. No.
12/15/2020	1004	U.S. Pat. App. Pub. No. 2008/0076489 Rosener	Public	Appx1404-1425
12/15/2020	1005	U.S. Pat. No. 7,627,289 Huddart	Public	Appx1426-1441
12/15/2020	1014	Plaintiff KOSS Corporations' Preliminary Infringement Contentions, KOSS Corporation v. Apple Inc.	Public	Appx1580-1582
12/23/2021	1023	Supplemental Declaration of Jeremy Cooperstock	Public	Appx2771-2800
12/23/2021	1024	Joseph C. McAlexander III Deposition Transcript	Public	Appx2801-2806, Appx2881, Appx2888, Appx2942, Appx2948-2952
12/23/2021	1026	U.S. Publication No. 2008/0119138 (Kim)	Public	Appx3192-3199
12/23/2021	1027	Jabra Talk 5 Datasheet	Public	Appx3200-3201
3/23/2021	2003	Docket Report, *Koss Corp. v. Apple Inc.*, Case 6-20-cv-00665-ADA (W.D. Tex.) (as of March 19, 2021).	Public	Appx3337, Appx3340
6/16/2021	2030	Claim Construction Order, *Koss Corp. v. Apple, Inc.*, Case No. 6-20-cv-00665-ADA, Dkt. 83 (W.D. Tex. June 2, 2021)	Public	Appx3953-3954
8/27/2021	2035	Declaration of Joseph C. McAlexander, III	Public	Appx4043-4048, Appx4064-4067
8/27/2021	2036	Declaration of Nicholas S. Blair	Public	Appx4125-4136
2/8/2022	2040	Deposition Transcript, Jeremy Cooperstock, Ph.D., January 18, 2022	Public	Appx4255-4261, Appx4272-4273, Appx4284-4287

Filing Date	Exhibit/ Paper No.	Document Name	Availability	Appx. No.
1/4/2021	2	Petition for Inter Partes Review	Public	Appx4426, Appx4432, Appx4452, Appx4456-4457, Appx4460-4461, Appx4466-4467
4/9/2021	9	Patent Owners Updated Mandatory Notices	Public	Appx4547-4548
7/2/2021	15	Trial Instituted Document	Public	Appx4630-4631, Appx4638, 4662
9/28/2021	19	Patent Owner's Response	Public	Appx4735-4743
12/21/2021	31	Petitioners Reply to Patent Owners Response	Public	Appx4831, Appx4849-4853
8/9/2022	44	Patent Owner's Notice of Appeal	Public	Appx5023-5025
1/4/2021	1003	Declaration of Dr. Jeremy Cooperstock	Public	Appx5512, Appx5516-5518, Appx5529, Appx5543-5544, Appx5578, Appx5632-5637
1/4/2021	1004	U.S. Pat. App. Pub. No. 2008/0076489 Rosener	Public	Appx5699-5720
1/4/2021	1005	U.S. Pat. App. Pub. No. 2008/0166001 Hankey	Public	Appx5721-5810
1/4/2021	1006	U.S. Pat. No. 8,031,900 Dyer	Public	Appx5811-5823
12/21/2021	1024	Supplemental Declaration of Jeremy R. Cooperstock	Public	Appx7389, Appx7396-7402
12/21/2021	1025	Joseph C. McAlexander III Deposition Transcript	Public	Appx7425-7430, Appx7616-7618
12/21/2021	1027	U.S. Pat. No. 5,733,598 to Sera	Public	Appx7748-7767

Filing Date	Exhibit/ Paper No.	Document Name	Availability	Appx. No.
9/28/2021	2037	Deposition Transcript, Jeremy Cooperstock, Ph.D., Sept. 13, 2021, IPR2021-00381	Public	Appx8680-8685, Appx8716-8729, Appx8734-8741, Appx8746
9/28/2021	2038	Declaration of Joseph C. McAlexander III	Public	Appx8818-8823, Appx8829, Appx8842-8851
9/28/2021	2039	Declaration of Nicholas S. Blair	Public	Appx8909-8910, Appx8921-8922

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Paper 47
Entered: May 31, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS COPRORATION,
Patent Owner.

IPR2021-00305
Patent 10,506,325 B1

Before DAVID C. MCKONE, GREGG I. ANDERSON,
and NORMAN H. BEAMER, *Administrative Patent Judges*.

MCKONE, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining Some Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition (Paper 2, "Pet.") requesting *inter partes* review of claims 1–4, 9, 10, and 14–18 of U.S. Patent No. 10,506,325 B1 (Ex. 1001, "the '325 patent"). Pet. 1. Koss Corp. ("Patent Owner") filed a Preliminary Response (Paper 9, "Prelim. Resp."). Pursuant to our authorization, Petitioner filed a Preliminary Reply (Paper 12) and Patent Owner filed a Preliminary Sur-Reply (Paper 13). Pursuant to 35 U.S.C. § 314, we instituted this proceeding. Paper 14 ("Dec.").

Patent Owner filed a Patent Owner's Response (Paper 20, "PO Resp."), Petitioner filed a Reply to the Patent Owner's Response (Paper 35, "Reply"), and Patent Owner filed a Sur-reply to the Reply (Paper 42, "Sur-reply"). An oral argument was held in this proceeding on March 3, 2022. Paper 46 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This Decision is a final written decision under 35 U.S.C. § 318(a) as to the patentability of claims 1–4, 9, 10, and 14–18. Based on the record before us, Petitioner has proved, by a preponderance of the evidence, that claims 1–4, 9, 10, and 14–17 are unpatentable, but has not proved that claim 18 is unpatentable.

B. Related Matters

1. Lawsuits

Petitioner advises us that it is a defendant in a case filed by Patent Owner asserting the '325 patent in the United States District Court for the Western District of Texas ("Texas court") captioned *Koss Corp. v. Apple Inc.*, Case No. 6:20-cv-00665 (W.D. Tex.) ("Texas case"). Pet. 79; *see also* Paper 11, 1. Patent Owner identifies another three lawsuits where Patent

Owner is plaintiff and the ’325 patent is asserted against other parties. Paper 11, 1. Patent Owner identifies two other cases involving the ’325 patent, including one filed by Petitioner in the United States District Court for the Northern District of California captioned *Apple Inc. v. Koss Corp.*, Case No. 4:20-cv-05504 (N.D. Cal.). Paper 11, 1.

2. *Inter Partes Review Proceedings*

Patent Owner (Paper 11, 1–2; Paper 30, 1) lists the following *inter partes* review proceedings[1] challenging the ’325 patent or patents related to the ’325 patent:

Bose Corp. v. Koss Corp., IPR2021-00297, filed December 7, 2020, challenging U.S. Patent No. 10,368,155 B2;

Apple Inc. v. Koss Corp., IPR2021-00381, filed January 4, 2021, challenging U.S. Patent No. 10,491,982 B1;

Apple Inc. v. Koss Corp., IPR2021-00546, filed February 22, 2021, challenging U.S. Patent No. 10,206,025 B1;

Apple Inc. v. Koss Corp., IPR2021-00592, filed March 2, 2021, challenging U.S. Patent No. 10,469,934 B1;

Bose Corp. v. Koss Corp., IPR2021-00612, filed March 3, 2021, challenging U.S. Patent No. 10,206,025 B1;

Apple Inc. v. Koss Corp., IPR2021-00626, filed March 17, 2021, challenging U.S. Patent No. 10,206,025 B1;

Bose Corp. v. Koss Corp., IPR2021-00680, filed March 17, 2021, challenging U.S. Patent No. 10,469,934 B1, filed March 17, 2021;

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[1] *Apple Inc. v. Koss Corp.*, IPR2021-00255, filed November 25, 2020, and *Apple Inc. v. Koss Corp.*, IPR2021-00600, filed March 7, 2021, both challenging U.S. Patent No. 10,298,451 B1 are also pending.

Apple Inc. v. Koss Corp., IPR2021-00679, filed March 22, 2021, challenging the '325 patent;

Apple Inc. v. Koss Corp., IPR2021-00686, filed March 22, 2021, challenging U.S. Patent No. 10,491,982 B1;

Apple Inc. v. Koss Corp., IPR2021-00693, filed March 23, 2021, challenging U.S. Patent No. 10,469,934 B1;

Apple Inc. v. Koss Corp., IPR2022-00053, filed October 15, 2021, challenging U.S. Patent No. 10,206,025 B1; and

Apple Inc. v. Koss Corp., IPR2022-00188, filed November 15, 2021, challenging U.S. Patent No. 10,469,934 B1.

C. The '325 Patent

The '325 patent describes wireless earphones or headphones. Ex. 1001, 2:3–5. Figure 1D, reproduced below, illustrates an example:

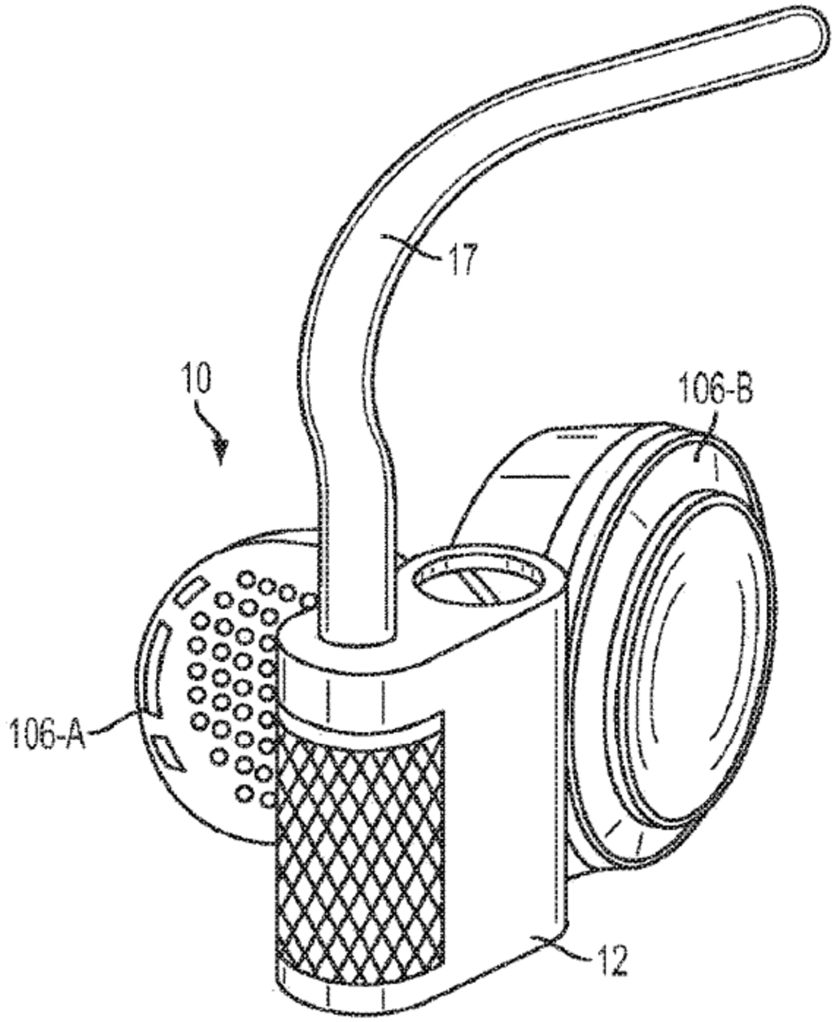

FIG. 1D

Figure 1D is a perspective drawing of a wireless earphone. *Id.* at 2:30–31, 4:7. In this embodiment, earphone 10 includes hanger bar 17 that allows earphone 10 to clip to, or hang on, a listener's ear. *Id.* at 4:4–7. Speaker element 106-A is sized to fit into the cavum concha of the listener. *Id.* at 4:10–12. Hanger bar 17 includes a horizontal section that rests upon the upper external curvature of the listener's ear behind the upper portion of the auricula (or pinna). *Id.* at 4:14–18.

Certain features of an embodiment of a wireless earphone are depicted in Figure 3, reproduced below:

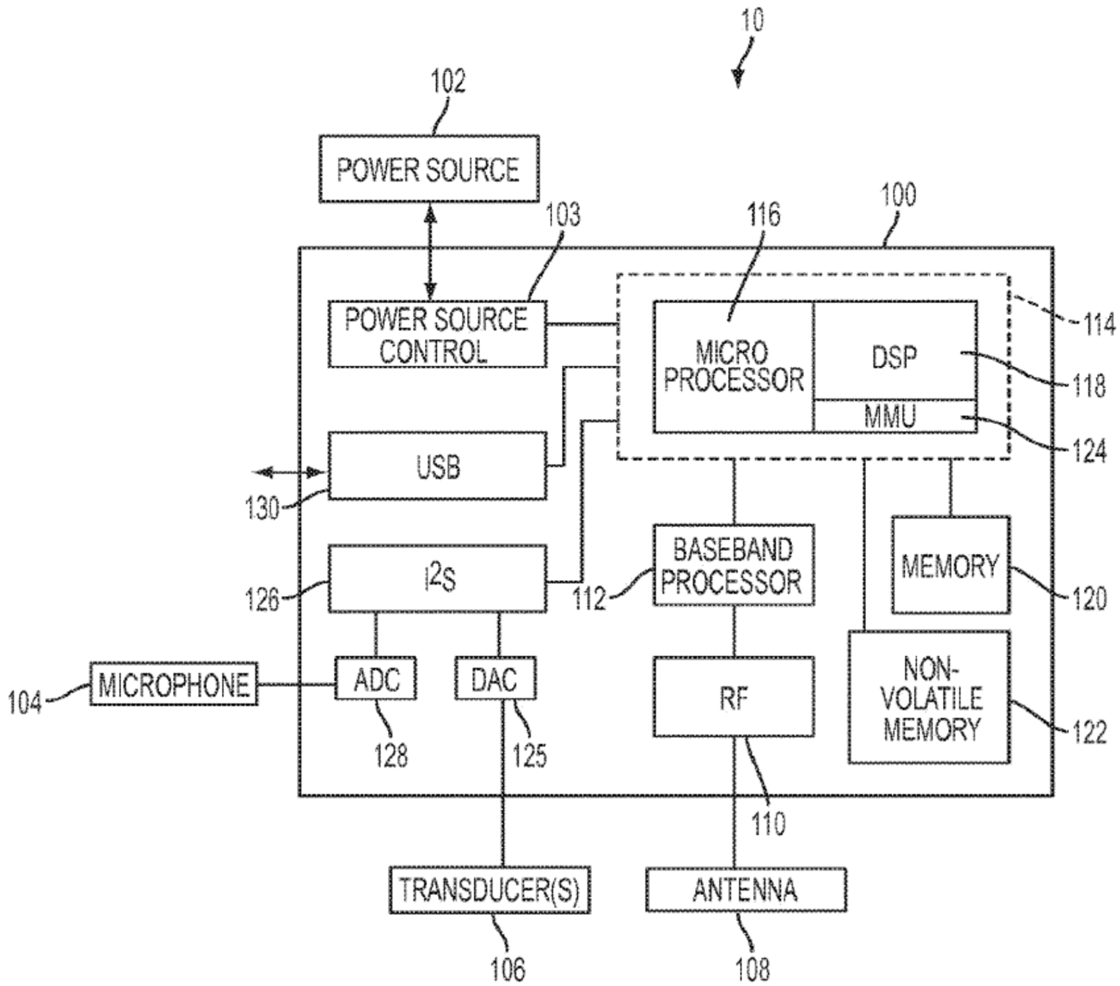

FIG. 3

Figure 3 is a block diagram of a wireless earphone. *Id.* at 2:35–36, 6:30–31.

Earphone 10 includes transceiver circuit 100, power source 102, microphone 104, acoustic transducer 106 (e.g., a speaker), and antenna 108. *Id.* at 6:31–37. Transceiver circuit 100, power source 102, and acoustic transducer 106 may be housed within body 12 of earphone 10 (shown in Fig. 1D above). *Id.* at 6:37–40. Microphone 104 and antenna 108 are external to body 12. *Id.* at 6:40–42. Earphone 10 incudes baseband processor 112 in communication with processor unit 114 which, in turn, includes microprocessor 116 and digital signal processor (DSP) 118. *Id.* at

7:30–32. DSP 118 "may . . . perform various sound quality enhancements to the digital audio received by the baseband processor 112, including noise cancellation and sound equalization." *Id.* at 7:34–38. Processor unit 114 executes firmware that may be stored on memory units 120, 122. *Id.* at 7:43–46. The '325 patent describes headphone 10 receiving firmware upgrades from a host server when earphone 10 is connected to a client computer device through a USB port and/or docking station. *Id.* at 9:50–56. "The power source 102 may comprise, for example, a rechargeable or non-rechargeable battery (or batteries). . . . In embodiments where the power source 102 comprises a rechargeable battery cell . . ., the battery cell . . . may be charged for use, for example, when the earphone 10 is connected to a docking station or computer." *Id.* at 6:56–65.

Earphone 10 may interface with an external device, such as the docking station shown in Figure 4A, reproduced below:

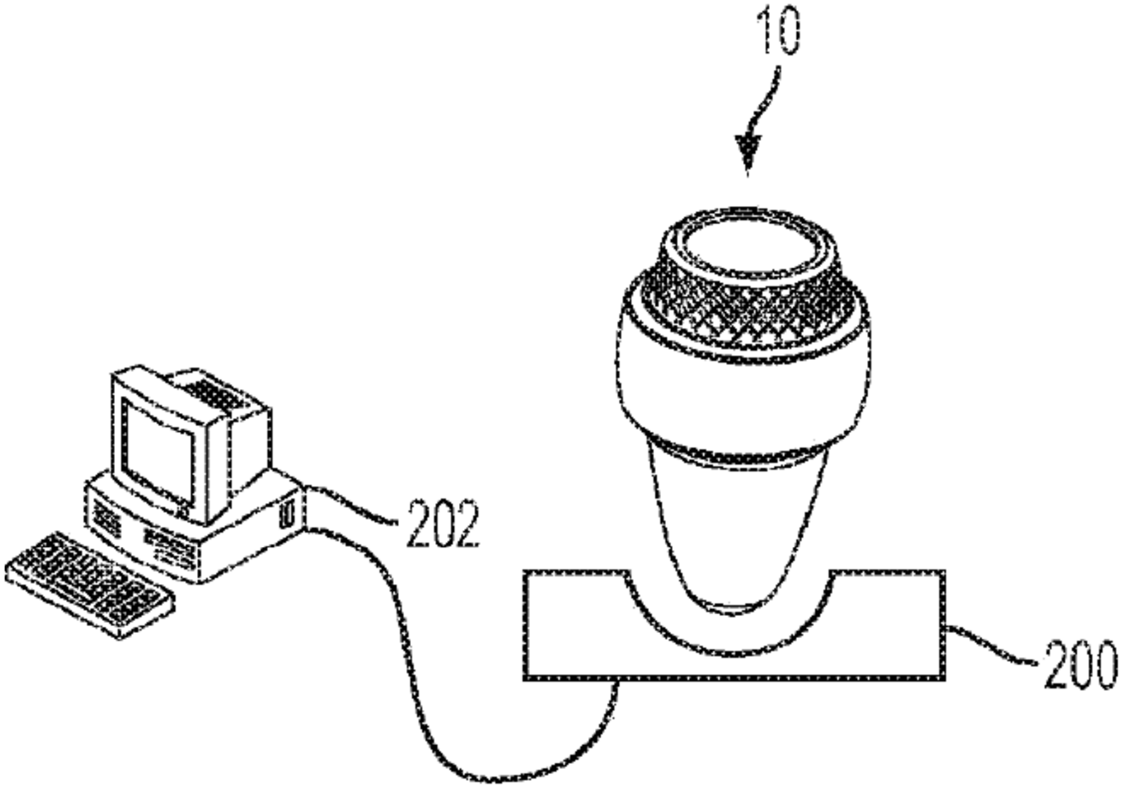

FIG. 4A

Figure 4A is a drawing showing earphone 10 interfacing with docking station 200, which is connected to computer device 202. *Id.* at 7:64–66. Earphone 10 may connect to docking station 102 to charge up power source 102 and to download data or firmware. *Id.* at 8:5–8.

Claims 1, 9, and 18, reproduced below, are illustrative of the claimed subject matter:

1. Headphones comprising:

a pair of first and second wireless earphones to be worn simultaneously by a user, wherein the first and

second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected, wherein each of the first and second earphones comprises:

a body portion;

an earbud extending from the body portion that is inserted into an ear of the user when worn by the user;

a curved hanger bar connected to the body portion, wherein the curved hanger bar comprises a portion that rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user;

a wireless communication circuit for receiving and transmitting wireless signals;

a processor circuit connected to the wireless communication circuit;

at least one acoustic transducer for producing audible sound from the earbud;

a microphone for picking up utterances of a user of the headphones;

an antenna connected to the wireless communication circuit; and

a rechargeable power source; and

a docking station for holding at least the first wireless earphone, wherein the docking station comprises a power cable for connecting to an external device to power the docking station, and wherein the docking station is for charging at least the first wireless earphone when the first wireless earphone is placed in the docking station.

9. The headphones of claim 1, the processor circuits of the headphones are configured to receive firmware upgrades transmitted from a remote network server.

18. The headphones of claim 1, wherein the processor circuit of each of the first and second earphones comprises:

a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone; and

a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

D. Evidence

Petitioner relies on the references listed below.

Reference		**Date**	**Exhibit No.**
Rosener	US 2008/0076489 A1	pub. Mar. 27, 2008	1004
Huddart	US 7,627,289 B2	pub. Dec. 1, 2009 filed Dec. 23, 2005	1005
Haupt	WO 2006/042749 A2	pub. Apr. 27, 2006	1006[2]
Price	US 2006/0026304 A1	pub. Feb. 2, 2006	1008
Paulson	US 7,551,940 B2	iss. June 23, 2009 filed Jan. 8, 2004	1009
Vanderelli	US 7,027,311 B2	iss. Apr. 11, 2006	1010

Petitioner also relies on the Declaration of Jeremy Cooperstock, Ph.D. (Ex. 1003, "Cooperstock Decl."), and the Supplemental Declaration of Dr. Cooperstock (Ex. 1023, "Supp. Cooperstock Decl.").

[2] We refer to a certified translation of the German language publication of WO 2006/042749.

Patent Owner relies on the Declaration of Joseph C. McAlexander III (Ex. 2035, "McAlexander Decl.") and the Declaration of Nicholas S. Blair (Ex. 2036, "Blair Decl.").

E. The Asserted Grounds

We instituted on the following grounds of unpatentability (Dec. 9):

Reference(s)	Basis	Claims Challenged
Rosener, Huddart	§ 103(a)[3]	1, 2, 16–18
Rosener, Huddart, Haupt	§ 103(a)	3, 4
Rosener, Huddart, Price	§ 103(a)	9, 10, 14
Rosener, Huddart, Paulson	§ 103(a)	15
Rosener, Huddart, Vanderelli	§ 103(a)	16, 17

II. ANALYSIS

A. Claim Construction

We construe a claim

> using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

37 C.F.R. § 42.100(b) (2019); *see also Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc).

[3] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103. Because the '325 patent claims an effective filing date before March 16, 2013, the effective date of the relevant amendment, the pre-AIA version of § 103 applies.

Petitioner contends that no formal claim constructions are necessary. Pet. 18. Patent Owner does not state a position on claim construction, but does not propose any constructions. *See, generally,* PO Resp.

Based on the complete record, we do not find it necessary to provide express claim constructions for any terms. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (noting that "we need only construe terms 'that are in controversy, and only to the extent necessary to resolve the controversy'") (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)).

B. Obviousness of Claims 1, 2, and 16–18 over Rosener and Huddart

Petitioner contends that claims 1, 2, and 16–18 would have been obvious over Rosener and Huddart. Pet. 18–56. For the reasons given below, Petitioner has made a sufficient showing as to claims 1, 2, and 16, but not claim 18. We do not reach claim 17 as to this ground, but do address claim 17's patentability in Petitioner's ground asserting Rosener, Huddart, and Vanderelli in Section II.F below.

A claim is unpatentable under 35 U.S.C. § 103 if the differences between the claimed subject matter and the prior art are "such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." We resolve the question of obviousness on the basis of underlying factual determinations, including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) objective evidence of nonobviousness, i.e., secondary considerations. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

1. Level of Skill in the Art

Dr. Cooperstock testifies that a skilled artisan "would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks." Ex. 1003 ¶ 34. In the Institution Decision, we found Dr. Cooperstock's testimony to be consistent with the technology described in the Specification and the cited prior art and adopted this level of skill for purposes of that Decision. Dec. 24.

Mr. McAlexander testifies that a skilled artisan "would be someone working in the electrical engineering field and specializing in or knowledgeable of speaker components for small wireless devices," and "would have had a bachelor's degree in electrical engineering and at least two or more years of work experience in the industry. Ex. 2035 ¶ 19. According to Mr. McAlexander, "[s]uch a person would have studied and have practical experience with circuit design, speaker components, and wireless communication." *Id.* Patent Owner states that this proposed level of skill "is not far removed from Petitioner's [person of ordinary skill in the art]." PO Resp. 6.

As Patent Owner acknowledges that the proposed levels of skill are similar, and does not argue that a difference in level of skill would lead to a different result in this proceeding, we continue to adopt Petitioner's proposed level of skill.

2. Scope and Content of the Prior Art

a) Overview of Rosener

Rosener describes wireless systems with "first and second data sinks having no physical or electrical connection therebetween." Ex. 1004, Abstract. The data sinks can be, for example, wireless earphones. *Id.* ¶ 2. Each wireless earphone may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear, and includes a housing containing a speaker, a radio-frequency (RF) transceiver, and a battery. *Id.* ¶ 30.

Each earphone may also include "a clip, earloop, or other suitable securing mechanism to help maintain the earphone . . . on the ear of the user." *Id.* Although Rosener does not have a figure showing a clip or earloop along with a preferred embodiment of the invention, it does depict, in Figure 4 (reproduced below) an earloop used with a prior art Bluetooth-enabled over-the-ear wireless headset:

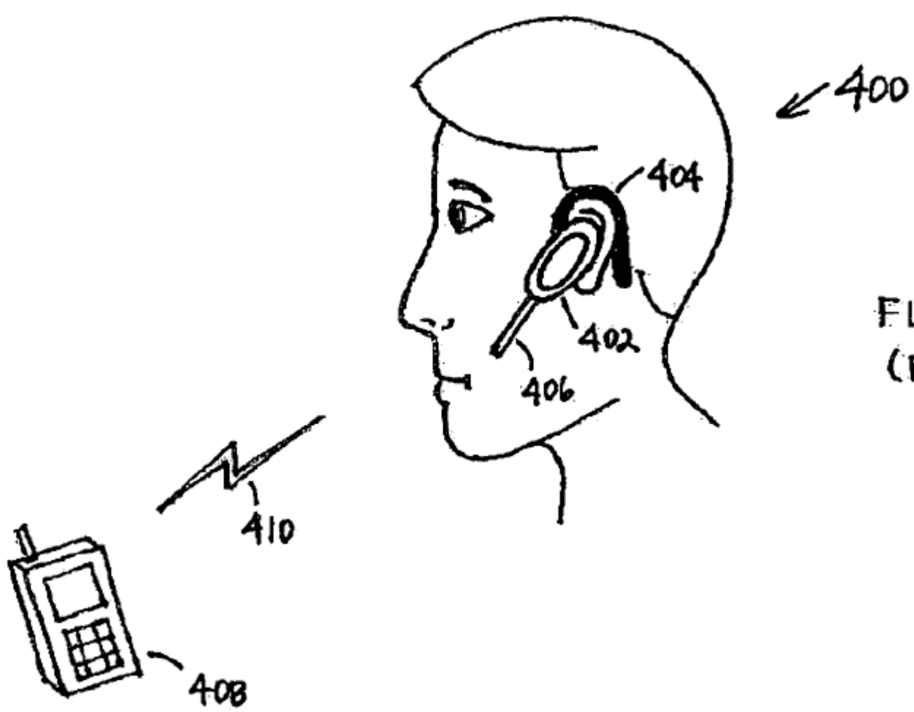

FIGURE 4
(PRIOR ART)

Figure 4 is a drawing of a user wearing a Bluetooth-enabled over-the-ear monaural wireless headset. *Id.* ¶ 17. As shown in Figure 4, headphone 402 includes earloop 404 that is configured to fit around the outer ear of user 400. *Id.* ¶ 8. Figure 5, reproduced below, shows earbuds, but not earloops:

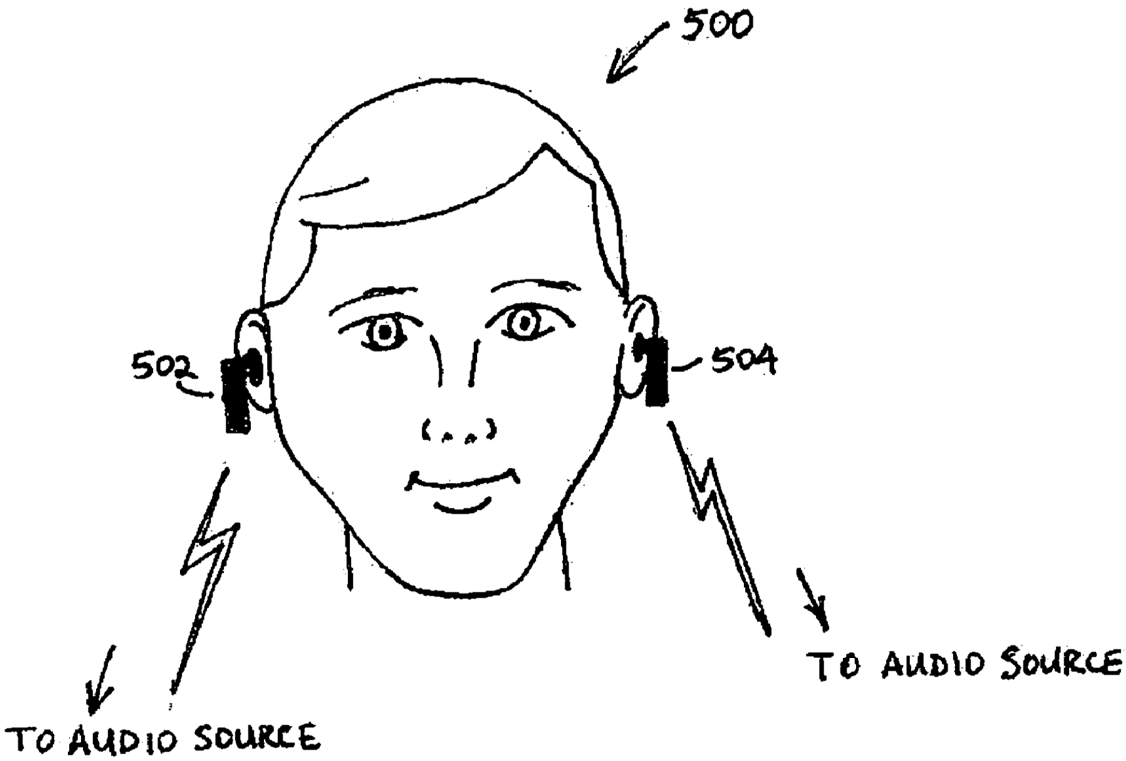

FIGURE 5

Figure 5 is an illustration of the head of a person wearing a headset comprising first and second wireless earphones 502, 504. *Id.* ¶¶ 18, 30.

Figure 9, reproduced below, illustrates some of the components of Rosener's headphones:

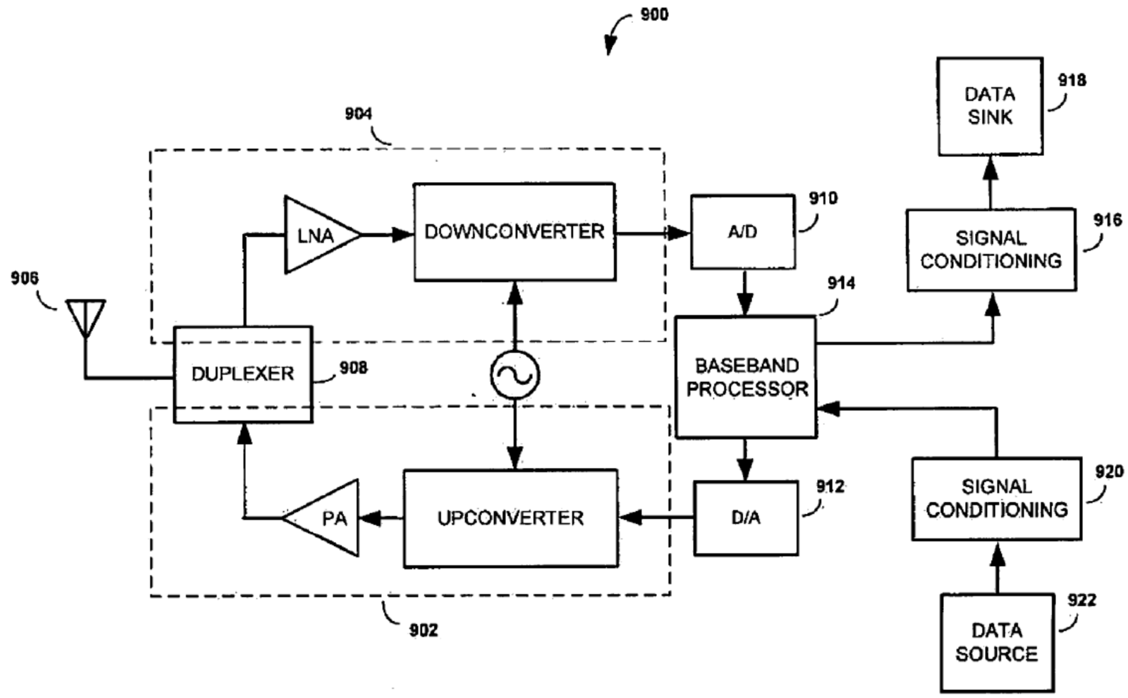

FIGURE 9

Figure 9 is a block diagram of an RF transceiver. *Id.* ¶¶ 24, 49.

RF transceiver 900 includes RF transmitter portion 902, RF receiver portion 904, antenna 906, and duplexer 908. *Id.* ¶ 49. A/D converter 910 receives analog baseband signals from RF transceiver portion 904, digitizes the signals, and sends them to baseband processor 914, which, along with signal conditioning circuit 916, processes the signals into a form suitable to drive data sink (speaker) 918. *Id.* According to Rosener, signal conditioning circuit 916 provides "digital-to-analog conversion, filtering, amplification, and/or other signal processing functions, to ensure that the processed data is in a form suitable to drive the data sink 918." *Id.* Baseband processor 914 receives data from data source 922 (e.g., a microphone) via signal conditioning circuit 920 and provides the data to RF transmitter portion 902 for transmission via antenna 906. *Id.* ¶ 50.

b) Overview of Huddart

Huddart describes wireless stereo headsets. Ex. 1005, Abstract. Figure 1, reproduced below, illustrates an example:

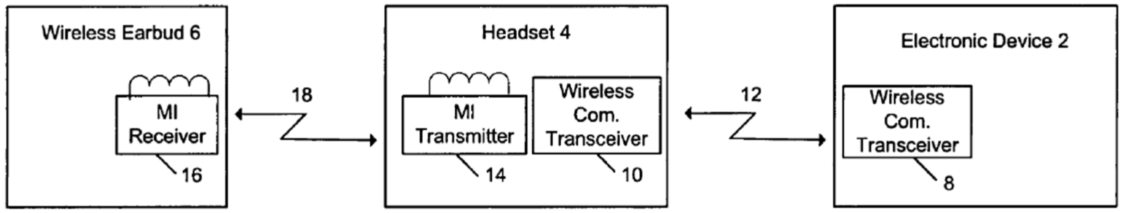

FIG. 1

Figure 1 is a system-view block diagram of a wireless stereo headset system. *Id.* at 1:44–45. Headset 4 is in proximity to electronic device 2 (e.g., a cellular telephone or digital music player), which transmits voice or text data to headset 4. *Id.* at 2:52–3:2. Headset 4 includes a speaker for one ear. "When stereo listening operation is desired by a user, a wireless earbud 6 is used in conjunction with headset 4. Both headset 4 and wireless earbud 6 have wireless communication functionality to form a wireless communication link 18." *Id.* at 3:7–10. "In one example of the invention, a magnetic induction wireless communication link is established between headset 4 and wireless earbud 6. Magnetic induction provides short range wireless communication at low power and cost while providing good audio signal quality." *Id.* at 3:19–23. "In further examples of the invention, other methods of wireless communication may be used to establish wireless communication link 18 between headset 4 and wireless earbud 6. For

example, wireless earbud 6 may be Bluetooth enabled to communicate with either headset 4 or electronic device 2." *Id.* at 3:55–60.

Wireless headset 4 "includes a power source such as a rechargeable battery installed within the housing to provide power to the various components of the receiver." *Id.* at 5:10–12. Similarly, "[w]ireless earbud 6 also includes a power source such as a rechargeable battery and a controller comprising a processor, memory and software to implement functionality as described herein." *Id.* at 5:26–29.

Huddart describes several options for charging the rechargeable batteries of wireless headset 4 and wireless earbud 6, including:

> a charger/carrier, such as a pocket charger, including a small plastic storage case for storing the headset 4 and wireless earbud 6 for protection and charging. The pocket charger includes a battery and charger circuit for charging both the headset battery and wireless earbud battery when inserted into the pocket charger/carrier.

Id. at 8:25–31;

> a charging coil to provide charging current to the wireless earbud battery 84 via receive aerial 52 shown in FIG. 4. The earbud advantageously does not require charging contacts on its small exterior surface when charging is performed with inductive charging. In this example, the single receive aerial 52 functions multiply to receive charging power for battery 84, generate a wake up signal 82, or receive an audio signal carrier.

Id. at 8:35–42; and

> a primary charger to which the pocket charger may be removably attached. The primary charger may be a cable or docking facility connecting the pocket charger/carrier to a wall outlet or primary batter[y] such as a car battery, allowing the headset battery, wireless earbud battery, and the storage case battery to be charged using the wall outlet or primary battery.

Id. at 8:51–57.

3. *Differences, if any, Between Claim 1 and the Prior Art; Reasons to Modify or Combine*

In essence, Petitioner contends that Rosener teaches the aspects of claim 1 regarding the components of the "pair of first and second wireless earphones," including a power source (although not necessarily a rechargeable power source), and that Huddart teaches the "rechargeable power source" and "docking station" aspects. Pet. 26–30. Patent Owner contests whether Rosener teaches "a curved hanger bar connected to the body portion, wherein the curved hanger bar comprises a portion that rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user," as recited in claim 1. PO Resp. 11–20. However, Patent Owner does not challenge any of Petitioner's other allegations for claim 1. We first address the contested "hanger bar" limitation of claim 1 and then address the uncontested limitations.

a) *Contested "hanger bar" limitation of claim 1*

As to "a body portion," as recited in claim 1, Petitioner cites to the "housing" of Rosener's earphones 502, 404. Pet. 32 (citing Ex. 1004 ¶ 30). We find that the housing of earphones 502, 504 is "a body portion." The parties dispute whether Rosener teaches "a curved hanger bar connected to the body portion, wherein the curved hanger bar comprises a portion that rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user," as recited in claim 1.

Petitioner (Pet. 34–35) points to Rosener's description that "[e]ach of the first and second earphone 502, 504 may further include a clip, earloop, or other suitable securing mechanism to help maintain the earphone 502 or 504 on the ear of the user." Ex. 1004 ¶ 30. According to Petitioner, a

skilled artisan would have understood from this description that each of earphones 502, 504 is connected to an earloop, which is an example of a curved hanger bar. Pet. 35.[4]

Petitioner (Pet. 35–36) argues that this description should be read in the context of Rosener's description of the prior art Bluetooth-enabled over-the-ear wireless headset depicted in Figure 4 (reproduced above), that "[t]he headset includes a headphone 402 and an earloop 404 that is configured to fit around the outer ear of the user 400." Ex. 1004 ¶ 8. *See also* Ex. 1003 ¶ 82 ("Though not shown in Figure 5, a [person of ordinary skill in the art] would have understood through this textual description that Rosener's disclosure contemplates some embodiments in which the housing of each of earphones 502, 504 is connected to, for example, an earloop ('curved hanger bar') to improve the manner in which each of the earphones is secured to the user's ear, as taught in Rosener."). Petitioner included in the Petition the following annotated version of Figure 5 (reproduced below) illustrating what earloops on Rosener's earphones might look like:

[4] In the Institution Decision, we considered competing arguments regarding whether an "earloop" as discussed in Rosener is, in fact, a curved hanger bar or whether, instead, it is more akin to the elastic straps that might hold a face mask in place. Dec. 33–34. We found, on the preliminary record, that Rosener's earloop is a curved hanger bar. *Id.* Patent Owner does not argue in its Response that the earloop is not a curved hanger bar and we maintain that finding that it is a curved hanger bar on the complete record for the reasons given in the Institution Decision. *See* Paper 15, 8 ("Patent Owner is cautioned that any arguments not raised in the response may be deemed waived.").

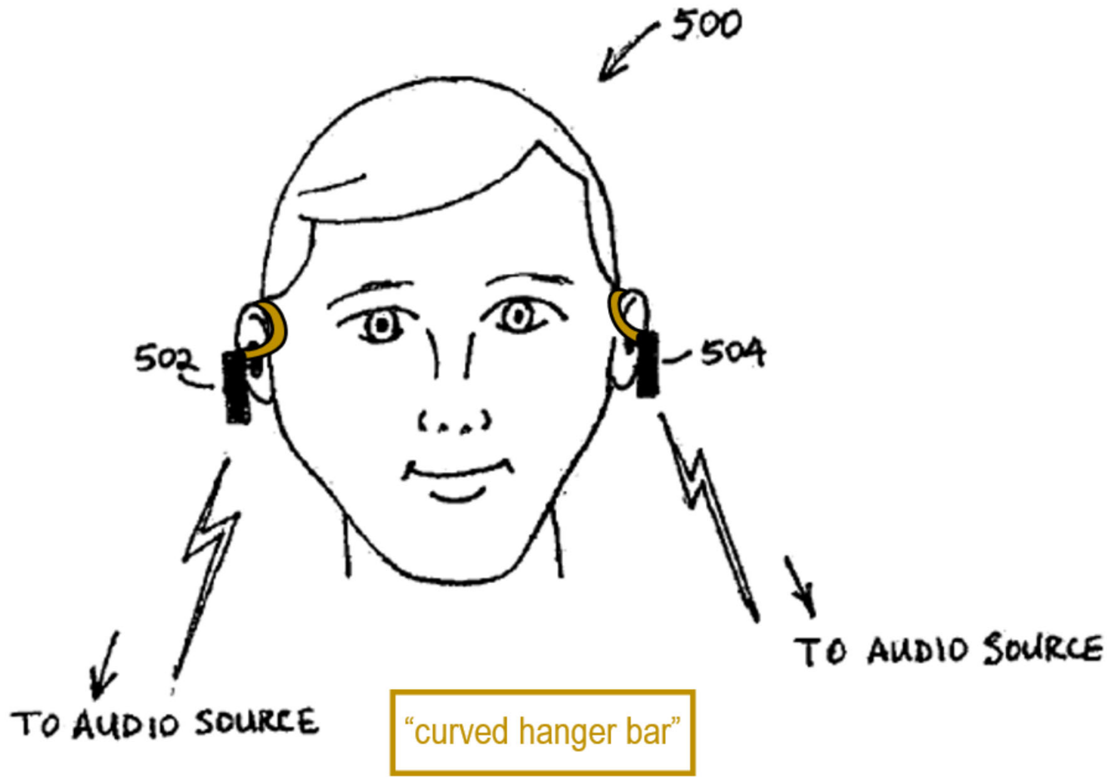

FIGURE 5

The figure above is a version of Rosener's Figure 5, annotated by Petitioner to add gold curved hanger bars to earphones 502, 504. Pet. 36. According to Petitioner, Rosener "thus teaches a system in which each of the elongated portions of the housings of earphones 502, 504 are connected to an earloop providing the same type of securing mechanism as shown for earloop 402," and "discloses this configuration given its teaching that each of earphones 502, 504 can include earloops and acknowledgement that use of earloops was conventional." *Id.* at 37 (citing Ex. 1004 ¶¶ 8, 30; Ex. 1003 ¶ 85).

Patent Owner characterizes Petitioner's position as asserting that "the earloop of Rosener's Figure 4 could be added to the wireless earphones of Rosener's Figure 5," that Petitioner's position relies on its modified version

of Figure 5, and that what Petitioner is arguing is that a skilled artisan would have combined two different embodiments of Rosener, one with the earbud and downwardly extending member of Figure 5 and another with the earloop of Figure 4. PO Resp. 14–15. Characterizing Petitioner's arguments in this way, Patent Owner then argues that a skilled artisan "would not have been motivated to add earloops to the earbud-downwardly extending member combination shown in Figure 5." *Id.* at 5.

Relying on the testimony of Mr. Blair, Patent Owner argues that, if one were to add the earloop of Figure 4 to the earbud and downwardly extending member of Figure 5, the earloop would effectively pry the earbuds out of the listener's ears. PO Resp. 16–18. According to Mr. Blair, the downwardly extending member of the earbud of Figure 5 exerts a downward force that holds the earbud in the ear, while the earloop of Figure 4 exerts a force upward and backward, counteracting the downward force and displacing the earbud from the ear. Ex. 2036 ¶¶ 14–17.[5]

Petitioner replies that Mr. Blair's testimony is conclusory and uncorroborated. Reply 10. Petitioner then argues that Patent Owner mischaracterizes what is shown in its annotated Figure 5 and contends that Mr. Blair's analysis of the various forces exerted on the earbuds is faulty. *Id.* at 10–15. In support, Petitioner offers testimony from Dr. Cooperstock, although that testimony is also conclusory and does not identify the basis for the testimony. Ex. 1023 ¶¶ 11–23.

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[5] Mr. McAlexander provides testimony that largely copies the arguments in Patent Owner's Response. Ex. 2035 ¶¶ 37–43. His testimony, however, does not appear to be based upon his own knowledge or expertise and, instead, is based upon his reading of Mr. Blair's testimony. We accord this testimony by Mr. McAlexander little weight.

We need not evaluate which of the experts' views on the various forces on a Figure 4/5 combination would have been correct. Patent Owner improperly limits Petitioner's arguments (and Rosener's disclosure) to a combination of separate embodiments shown alternately in Figures 4 and 5. We agree with Petitioner (Pet. 34–35; Reply 18) and find that Rosener expressly describes earbuds with curved hanger bars. Specifically, Rosener states that "[e]ach of the first and second earphones 502, 504 may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear," and that "[e]ach of the first and second earphone 502, 504 may further include a clip, earloop, or other suitable securing mechanism to help maintain the earphone 502 or 504 on the ear of the user." Ex. 1004 ¶ 30. We read Petitioner's annotated Figure 5 (shown above) as an illustration of how these expressly described features might look together, as Rosener does not have a figure depicting that embodiment. Petitioner relies on Figure 4 to show that "earloops" in fact correspond to "curved hanger bars," not to show precise structure that would be bodily incorporated into the embodiment depicted in Figure 5. We do not read Petitioner's annotated Figure 5 as a proposed physical combination of different embodiments within Rosener. Patent Owner's characterization of Petitioner's combination is not the correct lens through which we analyze obviousness. *See In re Keller*, 642 F.2d 413, 425 (Fed. Cir. 1981) ("To justify combining reference teachings in support of a rejection it is not necessary that a device shown in one reference can be physically inserted into the device shown in the other.").

Patent Owner argues that "Rosener . . . never states which listed earphone forms (e.g., earbud, canalphone, or over-the-ear) could also include an earloop." PO Resp. 19–20. In the Sur-reply, Patent Owner argues that Rosener "describes three separate earphone form factors (i.e.,

earbud, canalphone and over-the-ear circum-aural), but only links one of them—over-the-ear circum-aural—with an earloop. Rosener describes that the first two types—earbuds and canalphones—fit 'into' or 'within' the user's ear." Sur-reply 9–10.

We disagree. Rosener states that earphones 502, 504 could be earbuds and further states that they could include a clip or earloop to help maintain them on the ear of the user. Ex. 1004 ¶ 30. Although other options would be within the scope of this disclosure (e.g., an over-the-ear earphone with an earloop), we see no description in Rosener that would limit Rosener's clip or earloop to only some earphone form factors, and specifically find that Rosener's description of an earloop helping maintain the earphone "on the ear of the user," Ex. 1004 ¶ 30, is not an attempt to exclude earbuds. In sum, we find that Rosener expressly teaches "a curved hanger bar connected to the body portion, wherein the curved hanger bar comprises a portion that rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user," as recited in claim 1.

b) Uncontested limitations of claim 1

Regarding "a pair of first and second wireless earphones to be worn simultaneously by a user, wherein the first and second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected," as recited in claim 1, Petitioner (Pet. 30–32) cites to Rosener's earphones 502, 504, which "may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear" and are "physically and electrically-separated" with "no physical or electrical connection" between them. Ex. 1004 ¶¶ 11, 30, Fig. 5. Based

on this evidence, we find that Rosener's earphones 502, 504 teach this limitation.

As to an "earbud extending from the body portion that is inserted into an ear of the user when worn by the user," Petitioner points to earphones 502, 504, shown in Figure 5 as extending from a portion inserted into a user's ear. Pet. 33–34. As Petitioner notes (Pet. 33), Rosener describes earphones 502, 504 as "in the form of an earbud designed to fit into the concha of the pinna of the user's ear." Ex. 1004 ¶ 30. We find that Rosener teaches this limitation as well.

Petitioner contends that Rosener's RF transmitter portion 902, RF receiver portion 904, duplexer 908, A/D converter 910, and D/A converter 912, together constitute "a wireless communication circuit for receiving and transmitting wireless signals." Pet. 37–39 (citing Ex. 1004 ¶¶ 11, 30–36, 49, Figs. 5, 9). We agree. For example, Rosener teaches "[w]ireless systems having a plurality of physically and electrically-separated data sinks . . . . An exemplary wireless system includes first and second data sinks having no physical or electrical connection therebetween." Ex. 1004 ¶ 11.

Petitioner further contends that Rosener's baseband processor 914, signal conditioning circuits 916, 920, and other described circuitry constitute "a processor circuit connected to the wireless communication circuit," as recited in claim 1. *Id.* at 39–41 (citing Ex. 1004 ¶¶ 39–43, 49, 50, Fig. 9). We agree. As noted above, baseband processor 914 receives digitized baseband signals and signal conditioning circuit 916 provides digital-to-analog conversion, filtering, amplification, and other processing. Ex. 1004 ¶ 49.

Petitioner identifies Rosener's "data sink 918" as an "acoustic transducer," as recited in claim 1; Rosener's "data source 922" as "a

microphone for picking up utterances of a user of the headphones"; and Rosener's "antenna 906" as "an antenna connected to the wireless communication circuit." *Id.* at 41–44 (citing Ex. 1004 ¶¶ 2, 30 ("The speaker may comprise, for example, a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements."), 50 ("For the RF transmitter portion 902, a D/A converter 912 is adapted to receive data signals from a data source 922 and operable to convert the data signals into analogs signals, which are upconverted to RF by the RF transmitter in preparation of being radiated over the appropriate wireless link by the antenna 906."), 56 ("a microphone to allow . . . data to be sent back to an external electronic device"), Fig. 9). We find that Rosener teaches each of these limitations.

As to "a rechargeable power source," as recited in claim 1, Petitioner argues that Rosener describes a battery, but concedes that "Rosener does not explicitly describe the batteries being rechargeable." Pet. 44–45 (citing Ex. 1004 ¶ 30). Petitioner contends that Huddart teaches a rechargeable battery. *Id.* at 45 (citing Ex. 1005, 5:26–30). According to Petitioner, "[t]o the extent that Rosener is deemed to not disclose rechargeable batteries, [a person of ordinary skill in the art] would have found it obvious to incorporate a rechargeable battery (e.g., earbud battery) as taught in Huddart into each of Rosener's earphones 502, 504 for providing power to earphone components." *Id.* Citing Dr. Cooperstock's testimony, Petitioner argues that a skilled artisan "would have understood . . . that Rosener's earphones could have incorporated rechargeable batteries since this configuration was conventional around the time of its disclosure, as demonstrated by Huddart." *Id.* at 27 (citing Ex. 1003 ¶ 48). Petitioner contends that rechargeable

batteries would have improved Rosener's earphones "by eliminating or reducing the need to periodically replace the batteries, thereby removing or reducing the cost of doing so and also improving user convenience." *Id.* (citing Ex. 1003 ¶ 49). Dr. Cooperstock further testifies that Rosener's earphones would have benefited from rechargeable batteries in the same manner as Huddart's earbuds, e.g., in that the user could avoid frequent battery replacements. Ex. 1003 ¶ 50. We credit Dr. Cooperstock's testimony and find that a skilled artisan would have had reasons to (e.g., cost, convenience, avoid the need to replace batteries) to incorporate Huddart's teaching of rechargeable batteries into Rosener's earphones, and would have had a reasonable expectation of success in doing so.

Petitioner also cites Huddart for "a docking station for holding at least the first wireless earphone," as recited in claim 1. Pet. 46. Specifically, Petitioner contends that Huddart's charger/carrier and primary charger are examples of a docking station. *Id.* (citing Ex. 1005, 8:25–34). Petitioner contends that Huddart's primary charger can be a cable or docking station facility that allows the charger/carrier to connect to a wall outlet or primary battery, and, thus, teaches "a power cable for connecting to an external device to power the docking station," as recited in claim 1. *Id.* at 46–47 (citing Ex. 1005, 8:51–57). Petitioner argues that Huddart's charger/carrier and primary charger are "for charging at least the first wireless earphone when the first wireless earphone is placed in the docking station," as recited in claim 1. *Id.* at 47 (citing Ex. 1005, 5:9–12, 5:26–30, 8:25–50). Huddart's charger/carrier is described as "a convenient mechanism by which the earbud 6, having a relatively smaller capacity battery due to its limited size, may be recharged in the absence of a primary charger." Ex. 1005, 8:31–34.

Relying on Dr. Cooperstock's testimony, Petitioner argues that Huddart's docking station would have "improve[d] battery capacity when a primary charger is unavailable or to avoid the inconvenience of having to frequently plug the charger into a wall outlet, for instance when traveling." *Id.* at 28 (citing Ex. 1003 ¶ 51). Petitioner also argues that Huddart's charger/carrier would have provided a storage case to prevent Rosener's earphones from being misplaced. *Id.* at 28–29 (citing Ex. 1003 ¶52).

We credit Dr. Cooperstock's testimony and find that Petitioner's proffered reasons to combine Rosener and Huddart have rational underpinning; that a skilled artisan would have combined Huddart's teachings of a docking station with Rosener's earbuds (with rechargeable batteries that would be recharged via the docking station); and that a skilled artisan would have had a reasonable expectation of success in combining these teachings.

Thus, Rosner and Huddart teach each limitation of claim 1.

4. *Differences, if any, Between Claims 2 and 16 and the Prior Art; Reasons to Modify or Combine*

Petitioner contends that claims 2 and 16 would have been obvious over Rosener and Huddart. Patent Owner does not contest the additional allegations for claims 2 and 16.

Claim 2 depends from claim 1 and adds:

> the wireless communication circuits are for receiving, wirelessly, streaming audio content;
>
> the at least one acoustic transducers are for playing the streaming audio content; and

> each of the first and second earphones comprises a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer.

Petitioner identifies Rosener's RF transmitter portion 902, RF receiver portion 904, duplexer 908, A/D converter 910, and D/A converter 912, collectively, as "wireless communication circuits . . . for receiving, wirelessly, streaming audio content." Pet. 47–49 (citing Ex. 1004 ¶¶ 30, 34, 36, 39–42, 49). Petitioner further identifies Rosener's speaker as "at least one acoustic transducer." *Id.* at 49 (citing Ex. 1004 ¶¶ 30 ("The speaker may comprise, for example, a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements."), 38). As to "a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer," Petitioner cites to Rosener's description of "data buffers in each of the first and second RF receivers 604, 608." *Id.* at 49–50 (citing Ex. 1004 ¶ 39). Based on the evidence presented in the Petition, we find that Rosener teaches each additional limitation of claim 2.

Claim 16 depends from claim 1 and adds "wherein the rechargeable power source comprises wirelessly chargeable circuit components." We agree with Petitioner (Pet. 50–51) and find that Huddart teaches this limitation through its description of inductive charging and that a skilled artisan would had reasons to combine Huddart's teaching of inductive charging with the teachings of Rosener, with a reasonable expectation of success. Ex. 1005, 8:35–50; Ex. 1003 ¶ 103.

5. Claim 17

Claim 17 recites "wherein the rechargeable power source comprises a passive, wireless rechargeable power source." Petitioner argues that "the claim language is not clear as to how a *passive* wireless rechargeable power source differs from other wireless rechargeable power sources." Pet. 51. Petitioner argues that claim 17 would have been obvious over Rosener, Huddart, and Vanderelli if claim 17 is construed in light of the Specification. Pet. 51. We address these allegations in Section II.F below. In the alternative, Petitioner argues that, if we adopt a broader construction of claim 17 that is "divorced from the '325 patent specification," we should find it taught by Rosener and Huddart. *Id.* at 51–52. Because we find that the combination of Rosener, Huddart, and Vanderelli teaches the additional limitation of claim 17, as explained below, we do not reach whether Rosener and Huddart teach this limitation under a broader construction. *See SAS Inst. Inc. v. Iancu*, 138 S. Ct. 1348, 1359 (2018) (holding that a petitioner "is entitled to a final written decision addressing all of the claims it has challenged"); *Bos. Sci. Scimed, Inc. v. Cook Grp. Inc.*, 809 F. App'x 984, 990 (Fed. Cir. 2020) (non-precedential) (recognizing that the "Board need not address issues that are not necessary to the resolution of the proceeding" and, thus, agreeing that the Board has "discretion to decline to decide additional instituted grounds once the petitioner has prevailed on all its challenged claims").

6. Differences, if any, Between Claim 18 and the Prior Art; Reasons to Modify or Combine

As to claim 18, for "wherein the processor circuit of each of the first and second earphones comprises: . . . a baseband processor circuit that is in

communication with the wireless communication circuit of the earphone," Petitioner cites to a description of Rosener's baseband processor 914 and associated circuitry. *Id.* at 55–56 (citing Ex. 1004 ¶¶ 30, 49, Fig. 9). We agree that baseband processor 914 is a baseband processor circuit, and Figure 9 depicts baseband processor 914 in communication with RF transmitter portion 902, RF receiver portion 904, duplexer 908, A/D converter 910, and D/A converter 912, the alleged "wireless communication circuit of the earphone." Patent Owner does not contest Petitioner's allegations for this limitation of claim 18.

The parties dispute whether Rosener and Huddart teach "wherein the processor circuit of each of the first and second earphones comprises: a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone," as recited in claim 18.

Petitioner cites to description of Rosener's signal conditioning circuit 916 and identifies that component as corresponding to the claimed digital signal processor (DSP). *Id.* at 53–55 (citing Ex. 1004 ¶¶ 30, 34, 36, 38, 49, Fig. 9). In particular, Petitioner points to Rosener's description that signal conditioning circuit 916 provides "digital-to-analog conversion, filtering, amplification, and/or other signal processing functions, to ensure that the processed data is in form suitable to drive the data sink 918." *Id.* at 54 (quoting Ex. 1004 ¶ 49). Dr. Cooperstock testifies that signal conditioning circuit 916 "would have conditioned the signal to, for example, reduce or eliminate the effects of noise on the signal through filtering, which enhances sound quality." Ex. 1003 ¶ 111.

Patent Owner argues that Rosener's signal conditioning circuit 916 is a digital-to-analog converter (DAC), rather than a DSP, as its purpose is to

drive the headphone's speaker (data sink 918). PO Resp. 22–24 (citing Ex. 1004 ¶¶ 30 49; Ex. 2035 ¶ 50). Patent Owner, relying on Mr. McAlexander's testimony, contends that a DSP "is a circuit that performs mathematical functions on digital signals (like digital audio signals when used with speakers and earphones)." *Id.* at 24 (citing Ex. 2035 ¶ 53). Patent Owner further argues that a DSP is a processor and, as such, "typically includes the building blocks of a processor, such as an Arithmetic Logic Unit, shift registers, and memory space." *Id.* (citing Ex. 2035 ¶ 54).

Petitioner does not appear to contest Patent Owner's arguments that a DSP must be a processor, with components like arithmetic logic units, shift registers, and memory space, that performs mathematical functions on digital signals. Reply 19–22.[6] Indeed, Petitioner provides no proposed construction in either the Petition or the Reply, and contends instead that DSP "should be interpreted based on . . . its plain meaning." Reply 21. Rather, Petitioner argues that signal conditioning circuit 916 is more than a DAC, and performs filtering, amplification, and other signal processing

[6] Petitioner does argue that Patent Owner is incorrect to suggest that a DSP must be embodied as a single chip or integrated circuit. Reply 21–22. We do not read Patent Owner's arguments to limit a DSP to a single chip. PO Resp. 25 (arguing that "[a] DSP is often embodiment as a single chip (i.e., integrated circuit)"). In any case, we see no persuasive evidence that would limit a DSP to a single chip or integrated circuit.

functions. *Id.* at 19–20 (citing Ex. 1004 ¶ 49).[7] Petitioner equates the filtering, amplification, and other signal processing performed by signal conditioning circuit 916 to the "noise cancelation and sound equalization" listed by the '325 patent as examples of "various sound quality enhancements" performed by DSP 114. Reply 22–23; Ex. 1001, 7:34–37.

Patent Owner responds that

> [m]erely because Rosener's signal conditioning circuit can perform amplification and filtering does not mean that the amplification and filtering are of ***digital*** signals. Thus, the amplification and filtering by Rosener's "signal conditioning circuit" do not even necessarily involve processing of digital signals. Also, neither Rosener nor Cooperstock explained why it would have been obvious that the amplification and filtering performed by Rosener's signal conditioning circuit would have been digital.

Sur-reply 12–13. Patent Owner's concern is well-founded. Dr. Cooperstock admits that filtering and amplification are techniques for processing analog as well as digital signals. Ex. 2040, 9:10–10:8. Rosener describes signal conditioning circuit 916 as receiving data (presumably in digital format) from baseband processor 914, performing processing including digital-to-

[7] Petitioner also argues, for the first time in the Reply, that "'digital-to-analog conversion' is an example of a 'signal processing function.'" Reply 20–21. If Petitioner is attempting to argue that a DAC is a DSP, Petitioner did not make such an argument in the Petition and we do not entertain it here. *See* Patent Trial and Appeal Board Consolidated Trial Practice Guide (Nov. 2019) ("TPG"), 73–74 ("While replies and sur-replies can help crystalize issues for decision, a reply or sur-reply that raises a new issue or belatedly presents evidence may not be considered."), *available at* https://www.uspto.gov/TrialPracticeGuideConsolidated. Nevertheless, Petitioner does not articulate that argument clearly or support it with persuasive evidence. Thus, the argument would not be persuasive even if considered.

analog conversion, filtering, and amplification, and producing an output suitable to drive data sink 918. Ex. 1004 ¶ 49. The most logical reading of this description is that signal conditioning circuit 916 receives a digital signal, converts it to an analog signal, and filters and amplifies that signal to condition it to appropriately drive a speaker. In other words, consistent with Mr. McAlexander's testimony, the filtering and amplification are part of the digital-to-analog conversion process that converts and conditions a signal to drive a speaker. Ex. 2035 ¶¶ 49–52. Petitioner does not expressly argue in the Petition or the Reply that the filtering and amplification are performed on digital signals, or provide persuasive evidence that would support such an argument. Pet. 53–55; Reply 19–23; Ex. 1003 ¶¶ 110–111; Ex. 1023 ¶¶ 35–41.

For the first time at the oral argument, Petitioner argues that Rosener's data sink 918 might receive a digital signal instead of an analog signal and, thus, the filtering and amplification performed in signal conditioning circuit 916 could be performed on digital signals. Tr. 22:17–23:13. Petitioner argues that this is taught in paragraph 36 of Rosener. *Id.* Petitioner further argues that Mr. McAlexander admitted on cross-examination that signal conditioning circuit 916 performs filtering in the digital domain. *Id.* at 54:12–57:1 (citing Ex. 1024, 162). Petitioner did not raise these arguments in its Petition or Reply and, therefore, we do not consider them. *See* TPG 85–86; *Dell Inc. v. Acceleron, LLC*, 818 F.3d 1293, 1301 (Fed. Cir. 2016).

Moreover, Petitioner's arguments would not be persuasive even if considered. Paragraph 36 of Rosener describes Rosner's Figure 6, reproduced below:

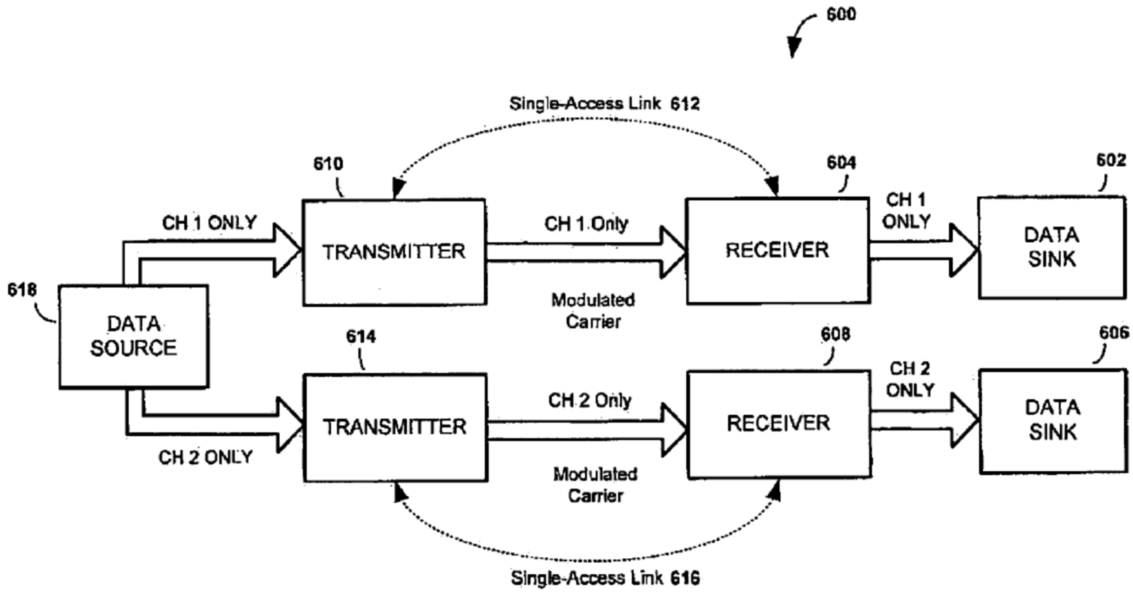

FIGURE 6

Figure 6 is a block diagram of a wireless system used to wirelessly transmit data signals to two or more data sinks. Ex. 1004 ¶19. First and second data streams are modulated onto RF carriers by first and second RF transmitters 601, 614 and transmitted wirelessly to first and second RF receivers 604, 608. *Id.* ¶ 36. RF receivers 604, 608 down-convert the modulated RF carriers and electrically couple the demodulated data streams to first and second data sinks 602, 606. *Id.* According to Rosener, the baseband portions of first and second RF receivers 604, 608 may also contain a DAC and/or other or additional processing circuitry to facilitate the electrical coupling of first and second RF receivers 604, 608 to first and second data sinks 602, 606. *Id.* "Alternatively, such components may be included as part of the data sinks 602, 606 themselves." *Id.*

Petitioner appears to argue that, here, Rosener describes a data sink with a DAC and, by implication, signal conditioning circuit 916 of Figure 9 would operate (filter, amplify) only on digital signals if connected to that

sort of data sink. We are not persuaded. Rosener does not explain how the components of Figure 9 would be used or modified if data sink 918 included a DAC. As noted above, the best reading of Rosener is that signal conditioning circuit 916 converts a digital signal to an analog signal and filters/amplifies that analog signal to put it into condition to drive a speaker. Presumably, if the DAC functionality is moved to data sink 918, the other signal conditioning functionality, such as filtering and amplification, would be moved as well, rendering signal conditioning circuit 916, as depicted, unnecessary (or incorporated into data sink 918). Petitioner offers no persuasive evidence that signal conditioning circuit 916 would perform sound quality enhancing digital signal processing in this scenario.

Mr. McAlexander's cross-examination testimony is not inconsistent with our reading of Rosener. Mr. McAlexander testifies that a signal conditioning circuit would have resistor-capacitor filters both before and after a DAC as part of signal conditioning, not digital signal processing. Ex. 1024, 162:2–164:12. Petitioner does not show persuasively that this would be digital signal processing to provide a sound quality enhancement for the audio content played by the speaker.

In sum, Petitioner has not shown, by a preponderance of the evidence, that the combination of Rosener and Huddart teaches "wherein the processor circuit of each of the first and second earphones comprises: a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone," as recited in claim 18.

Patent Owner raises a second dispute as to this claim limitation. Although it is not necessary to reach this dispute to assess the patentability of claim 18, Patent Owner refers to its claim 18 arguments when responding

to Petitioner's challenge to claims 9 and 10 (discussed in detail below). PO Resp. 34–35. Thus, we discuss Patent Owner's second argument for claim 18.

As noted above for claim 1, Petitioner contends that, "[t]o the extent that Rosener is deemed to not disclose rechargeable batteries, [a person of ordinary skill in the art] would have found it obvious to incorporate a rechargeable battery (e.g., earbud battery) as taught in Huddart into each of Rosener's earphones 502, 504 for providing power to earphone components." Pet. 45. Patent Owner does not contest these allegations for claim 1 and, for the reasons given above, we find that a skilled artisan would have combined the teachings of Rosener and Huddart for the limitation of claim 1, "a rechargeable power source."

Nevertheless, Patent Owner contests this limitation as it pertains to claim 18. Specifically, Patent Owner argues that Huddart does not describe a rechargeable battery that would be capable of powering Rosener's earbud if the earbud were to include a DSP and a baseband processor. PO Resp. 27–32. Patent Owner contends that Huddart describes a "relatively ***smaller capacity battery due to its limited size***." *Id.* at 28 (quoting Ex. 1005, 8:32–33). Patent Owner argues that Huddart's battery is recharged using a small plastic storage case and that "[i]f a larger-capacity battery was needed to power the additional components of the earbud, such as a DSP and baseband processor per claim 18, Huddart's pocket charger would not be suitable for charging the battery of the wireless earbud." *Id.* Patent Owner does not cite to evidence for this contention.

To support its contention that Huddart's battery is "low-power," Petitioner argues that Huddart describes its headset and wireless earbud as communicating using magnetic induction, which Huddart characterizes as

providing short range wireless communication at low power. *Id.* at 29 (citing Ex. 1005, 3:8–14, 3:21–23, 3:43–46). In contrast, Patent Owner argues, a DSP and a baseband processor are high-level integrated circuits that "consume and require a greater amount of battery power than a magnetic inductance receiver." *Id.* at 29–30 (citing Ex. 2035 ¶ 62). According to Patent Owner, "[g]iven the significant power requirements of a DSP and baseband processor, a [person of ordinary skill in the art] would not be motivated to use Huddart's low-power battery, which is designed to merely power a low-power magnetic inductance receiver and the related components of Huddart's earbud." *Id.* at 30. Patent Owner argues that "Huddart's low-power battery [would] be unreliable, undesirable, and/or incompatible for use to power the claimed DSP and baseband processor due to its small capacity." *Id.*

As noted above, communication via magnetic induction is only one example contemplated by Huddart, and Bluetooth communication is another described option. Ex. 1005, 3:19–60. Patent Owner dismisses this alternative, arguing that "Huddart fails to disclose whether a Bluetooth enabled earbud would be compatible with the low power battery discussed solely in connection with the magnetic induction communication system or whether a larger, higher power battery would be needed." PO Resp. 31. However, we see nothing in Huddart to suggest that the battery it describes would be insufficient to power its alternative embodiment.

Patent Owner also argues that the additional power needed for a DSP and baseband processor would increase the drain on Huddart's battery, causing it to generate heat that would be undesirable in an earbud worn on the face. PO Resp. 30–31 (citing Ex. 2035 ¶ 63). Patent Owner further

argues that a battery with a larger capacity than that of Huddart would have been too heavy to be used in a wireless earphone. *Id.* (citing Ex. 2035 ¶ 63).

Petitioner argues that Patent Owner misinterprets Petitioner's mapping of Rosener and Huddart to the claims. Reply 23–24. Specifically, Petitioner argues that Rosener teaches a rechargeable power source and that it "relie[s] on Huddart for its disclosure of an earbud battery being rechargeable and proposed modifying Rosener's battery to be similarly rechargeable." *Id.* at 23. In the Petition, Petitioner argues that

> While Rosener does not explicitly describe the batteries being rechargeable, a [person of ordinary skill in the art] would have understood that earphones 502, 504 could have been configured with rechargeable batteries since the use of such batteries in wireless devices was well-known before the Critical Date as shown, for example, Huddart's disclosure of its "wireless earbud" including a "power source such as a rechargeable battery."

Pet. 44–45. Petitioner continues, "[t]o the extent that Rosener is deemed to not disclose rechargeable batteries, [a person of ordinary skill in the art] would have found it obvious to incorporate a rechargeable battery (e.g., earbud battery) as taught in Huddart into each of Rosener's earphones 502, 504 for providing power to earphone components." *Id.* at 45; *see also id.* at 27 ("A [person of ordinary skill in the art] would have understood, however, that Rosener's earphones could have incorporated rechargeable batteries since this configuration was conventional around the time of its disclosure, as demonstrated by Huddart."). Petitioner further argues that Patent Owner does not contest that Rosener's battery, when modified to be rechargeable, would have been sufficient to power a digital signal processor. *Id.* at 23.

We agree with Petitioner. Petitioner did not contend in the Petition that a skilled artisan would have swapped Huddart's battery for Rosener's.

Indeed, that is not how we typically evaluate obviousness. *See In re Mouttet*, 686 F.3d 1322, 1332–33 (Fed. Cir. 2012) ("It is well-established that a determination of obviousness based on teachings from multiple references does not require an actual, physical substitution of elements. . . . Rather, the test for obviousness is what the combined teachings of the references would have suggested to those having ordinary skill in the art."). Instead, Petitioner argues that a skilled artisan would have made Rosener's battery rechargeable, as that would have eliminated the need to replace batteries and would have been more convenient to users, and that Huddart showed that it was well-known that earbuds could be equipped with rechargeable batteries. Pet. 27. We credit Dr. Cooperstock's testimony in support of these arguments. Ex. 1003 ¶¶ 48–50. Setting aside the issue whether signal conditioning circuit 916 is a DSP (above, we find that it is not), Patent Owner does not contest that Rosener's battery is at least sufficient to power the circuitry specifically described in Rosener, including signal conditioning circuit 916 and baseband processor 914. Tr. 46:17–21. We find that a skilled artisan would have had reasons, with rational underpinning, to use a rechargeable battery with Rosener's earphones (Huddart shows that this was conventional), and that the skilled artisan would have selected a rechargeable battery sufficient to power Rosener's circuitry.

7. Objective Indicia of Nonobviousness

Patent Owner argues that the commercial success of the invention of the challenged claims evidences nonobviousness. PO Resp. 37–42.

"[E]vidence of secondary considerations may often be the most probative and cogent evidence in the record." *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983). For example,

> Commercial success is relevant because the law presumes an idea would successfully have been brought to market sooner, in response to market forces, had the idea been obvious to persons skilled in the art. Thus, the law deems evidence of (1) commercial success, and (2) some causal relation or "nexus" between an invention and commercial success of a product embodying that invention, probative of whether an invention was non-obvious.

Merck & Co. v. Teva Pharms. USA, Inc., 395 F.3d 1364, 1376 (Fed. Cir. 2005). "[T]o be accorded substantial weight in the obviousness analysis, the evidence of secondary considerations must have a 'nexus' to the claims, *i.e.*, there must be 'a legally and factually sufficient connection' between the evidence and the patented invention." *Henny Penny Corp. v. Frymaster LLC*, 938 F.3d 1324, 1332 (Fed. Cir. 2019) (quoting *Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988)).

"[A] patentee is entitled to a rebuttable presumption of nexus between the asserted evidence of secondary considerations and a patent claim if the patentee shows that the asserted evidence is tied to a specific product and that the product '*is* the invention disclosed and claimed.'" *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019) (quoting *Demaco*, 851 F.2d at 1392). "That is, presuming nexus is appropriate 'when the patentee shows that the asserted objective evidence is tied to a specific product and that product embodies the claimed features, and is coextensive with them.'" *Id.* (quoting *Polaris Indus., Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1072 (Fed. Cir. 2018) (additional internal quotation marks omitted)). "Conversely, '[w]hen the thing that is commercially successful is not

coextensive with the patented invention—for example, if the patented invention is only a component of a commercially successful machine or process,' the patentee is not entitled to a presumption of nexus." *Id.* (quoting *Demaco*, 851 F.2d at 1392) (alteration by Federal Circuit). "'The patentee bears the burden of showing that a nexus exists.'"[8] *Id.* (quoting *WMS Gaming Inc. v. Int'l Game Tech.*, 184 F.3d 1339, 1359 (Fed. Cir. 1999)).

If we do not presume nexus, "[t]o establish a proper nexus between a claimed invention and the commercial success of a product, a patent owner must offer 'proof that the sales were a direct result of the unique characteristics of the claimed invention—as opposed to other economic and commercial factors unrelated to the quality of the patented subject matter.'" *SightSound Techs., LLC v. Apple Inc.*, 809 F.3d 1307, 1319 (Fed. Cir. 2015) (quoting *In re Huang*, 100 F.3d 135, 140 (Fed. Cir. 1996)); *accord Fox Factory*, 944 F.3d at 1373–74 ("A finding that a presumption of nexus is inappropriate does not end the inquiry into secondary considerations. To the contrary, the patent owner is still afforded an opportunity to prove nexus by showing that the evidence of secondary considerations is the 'direct result of the unique characteristics of the claimed invention.'" (quoting *Huang*, 100 F.3d at 140)).

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[8] The parties agree that Patent Owner bears the burden of persuasion on nexus. Reply 31–32; Tr. 51:3–22. In a related hearing conducted on the same day between the same parties, Patent Owner expressly agreed that it bears the burden of persuasion on the issue of nexus. IPR2021-00255, Paper 53 (Mar. 3, 2022, Oral Argument Transcript) at 43:8–23. Patent Owner stated that we can rely on that agreement in this proceeding. Tr. 51:3–22.

Patent Owner argues that the commercial success of the Powerbeats Pro, a product by Petitioner's subsidiary Beats by Dr. Dre, is objective evidence of the nonobviousness of the challenged claims.[9] PO Resp. 37–42. The parties dispute whether Patent Owner has shown a nexus between the commercial success of the Powerbeats Pro and the claimed invention.

Patent Owner argues that "[i]n light of the extreme coextensiveness between the Powerbeats Pro and claims 1–18 of the '325 Patent, the Board should presume a nexus between the commercial success of the Powerbeats Pro and claims 1–18." PO Resp. 41. In support of this argument that the Powerbeats Pro product is coextensive with the claimed invention, Patent Owner cites to its infringement contentions served in the Texas case, and argues that "claims 1–18 of the '325 Patent read on the Powerbeats Pro." *Id.* at 38 (citing Ex. 1014, 1079–113), 40 (same); Sur-reply 19 ("The [Patent Owner Response] cited an exhibit, APPLE-1014, 1079–1113, that includes a detailed claim chart showing that the PowerBeats Pros possess all the elements of the Challenged Claims."). Patent Owner does not provide a detailed comparison of the Powerbeats Pro with the challenged claims in its Response. PO Resp. 37–42. At most, Patent Owner points out certain features of the Powerbeats Pro, such as being "completely wireless" and having a "a signature earhook design." *Id.* at 37–38, 40. However, Patent Owner's attempt to incorporate its infringement contentions by reference into the Response is contrary to our rules, and those infringement

[9] Patent Owner's evidence of commercial success shows success at the level of a category that would include the Powerbeats Pro, but does not break out the Powerbeats Pro individually. PO Resp. 38, 41–42 (citing Exs. 2037, 2038). Nevetheless, Petitioner does not contest that the Powerbeats Pro product has been commercially successful.

contentions will be disregarded. *See* 37 C.F.R. § 42.6(a)(3) ("Arguments must not be incorporated by reference from one document into another document."). Accordingly, Patent Owner has not shown that the Powerbeats Pro practices the invention of the challenged claims and, for that reason, has not shown that the Powerbeats Pro is coextensive with the challenged claims.

Additionally, Petitioner points to features of the Powerbeats Pro, not recited in the challenged claims, that it alleges are responsible for the commercial success of that product. Reply 32–34. "Although we do not require the patentee to prove perfect correspondence to meet the coextensiveness requirement, what we do require is that the patentee demonstrate that the product is essentially the claimed invention." *Fox Factory*, 944 F.3d at 1374. On one hand, "if the unclaimed features amount to nothing more than additional insignificant features, presuming nexus may nevertheless be appropriate." *Id.* On the other, a claim is not coextensive with a product that includes a "critical" unclaimed feature that materially impacts the product's functionality. *Id.* at 1375.

In particular, Petitioner argues that the Powerbeats Pro includes a speech-detecting accelerometer in each earbud, two beam-forming microphones per side to help filter out sounds such as wind and ambient noise, a proprietary chip package that provides a faster and more stable wireless connection, and wireless audio sharing functionality and location tracking using a phone to determine if the headphones are lost or missing. Reply 32–33 (citing Ex. 1028; Ex. 2039, 3–4). Petitioner argues that these unclaimed features materially impact the Powerbeats Pro's functionality and points to product reviews to show that the proprietary chip package improves quality and latency. *Id.* at 33 (citing Exs. 1029, 1030).

Patent Owner responds that much of what Petitioner argues are unclaimed features are, in fact, claimed. Sur-reply 19–20. Specifically, Patent Owner argues that claim 1's recitation of a "microphone" corresponds to the two beam-forming microphones in Powerbeats Pro; the "processor circuit" of claim 1 corresponds to the proprietary chip package of Powerbeats Pro; and that claim 18's recitation of a "digital signal processor that provides a sound quality enhancement" corresponds to the speech-detecting accelerometer and two-beam forming microphones of Powerbeats Pro. *Id.* Patent Owner, however, offers no evidence to support these arguments.[10] *Id.* Patent Owner's attorney argument is not persuasive to meet its burden to show that the challenged claims are coextensive with Powerbeats Pro. In any case, we agree with Petitioner that these particular features of Powerbeats Pro do not appear to be coextensive with the recitations in claims 1 and 18. *Cf. Fox Factory*, 944 F.3d at 1376 ("On a broader note, if we were to agree . . . that the coextensiveness requirement is met so long as the patent claim broadly covers the product that is the subject of the secondary considerations evidence, irrespective of the nature of any

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[10] We recognize that, ordinarily, "[t]he sur-reply may not be accompanied by new evidence other than deposition transcripts of the cross-examination of any reply witness." TPG 73. In this instance, it is Patent Owner's burden to prove that the challenged claims are coextensive with the Powerbeats Pro in order to show nexus via coextensiveness. *See Fox Factory*, 944 F.3d at 1373. Thus, Patent Owner should have marshaled evidence of coextensiveness, including evidence as to unclaimed features, with its Response. Paper 15 (Scheduling Order) 8 (Patent Owner is cautioned that any arguments not raised in the response may be deemed waived."); TPG 73–74 ("Sur-replies should only respond to arguments made in reply briefs, comment on reply declaration testimony, or point to cross-examination testimony."). In any case, Patent Owner did not request an opportunity to submit additional evidence with its Sur-reply.

unclaimed features—then the coextensiveness requirement would rest entirely on minor variations in claim drafting.”). Moreover, Patent Owner does not contest that other features, such as wireless audio sharing functionality and location tracking using a phone, are features of Powerbeats Pro but not claimed in the challenged claims.

Patent Owner also argues that, even if the features of Powerbeats Pro are not claimed in the challenged claims, those features “are not for improving the ‘heart,’ or purpose, of the ’325 Patent.” Sur-Reply 20–21. In a similar argument, Patent Owner contends that “even if any of the Powerbeats Pro’s features identified in the Reply could be considered unclaimed, there is no evidence that they are critical or significant to performing the function of the ’325 Patent’s earphones better.” *Id.* at 21. Specifically, Patent Owner argues, “Petitioner . . . did not introduce any evidence to show that the speech-detecting accelerometer, beam-forming microphones, ambient noise filtering, wireless audio sharing and/or location tracking are critical to securing a pair of independently wireless earphones to the user.” *Id.* at 21–22. This misstates the law. *Fox Factory* did not hold that unclaimed features must be critical to or for improving the heart of the challenged claims. Rather, we look to whether the unclaimed features “materially impact[] the product’s functionality.” *Fox Factory*, 944 F.3d at 1375. Thus, when *Fox Factory* states that “if the unclaimed features amount to nothing more than additional insignificant features, presuming nexus may nevertheless be appropriate,” *id.* at 1374, it means insignificant to the product, not insignificant to the challenged claims. Patent Owner does not argue, and has not presented evidence, that the unclaimed features of Powerbeats Pro are insignificant to, or do not materially impact, the Powerbeats Pro product and its success.

For these reasons, even if we consider Patent Owner's improperly incorporated claim charts, we still conclude that Patent Owner has not met its burden to prove that the challenged claims and Powerbeats Pro are coextensive. Thus, Patent Owner has not shown a nexus between the commercial success of Powerbeats Pro and the invention of the challenged claims by virtue of coextensiveness.

As noted above, Patent Owner may still show nexus by showing that the commercial success of the Powerbeats Pro is the direct result of the unique characteristics of the claimed invention. *See Fox Factory*, 944 F.3d at 1373–74; *Huang*, 100 F.3d at 140. To that end, Patent Owner argues in the Response that "[a]t a minimum, a nexus between the Powerbeats Pro [and] the Challenged Claims exists because the commercial success is the direct result of the unique characteristics of the claimed invention." PO Resp. 41. Patent Owner does not cite to evidence to support this statement, and does not identify, in the Response which "unique characteristics" it relies on. *Id.*

In its arguments regarding coextensiveness, Patent Owner identified the "completely wireless" nature and "signature earhook design" of the Powerbeats Pro. *Id.* at 37–38, 40. In the Sur-reply, Patent Owner attempts to tie these two features to "unique characteristics" of the challenged claims. Sur-reply 23 ("The [Patent Owner Response] explained how Petitioner's press releases touted the 'completely wireless' nature of the headphones as well as the 'signature earhook design' of the PowerBeats Pros.") (citing PO Resp. 37–38; Ex. 2039, 1). Patent Owner has not shown persuasive evidence to support an argument that the commercial success of the Powerbeats Pro was the direct result of these features. The press release of Exhibit 2039 characterizes the Powerbeats Pro as

> completely wireless earphones that deliver powerful sound for the world's most passionate music lovers and motivated athletes. The result of a deep integration between Beats and Apple engineering, Powerbeats Pro features industry-leading battery life, advanced functionality, reliable connectivity, exceptional fit via the signature earhook design and beautiful fidelity.

Ex. 2039, 2. This press release purportedly published on April 3, 2019, (Ex. 2039, 2), while Patent Owner relies on commercial success that took place after this date, in "Q3 2019" (PO Resp. 41). Patent Owner does not explain persuasively why a press release published before the period of alleged commercial success is evidence of the reasons for that success.

In sum, we conclude that Patent Owner has not shown a nexus between the challenged claims and the alleged commercial success of the Powerbeats Pro. Accordingly, Patent Owner's objective indicia of nonobviousness is particularly weak and unpersuasive.

8. Conclusion of Obviousness

As explained above, the combination of Rosener and Huddart teaches each limitation of claims 1, 2, and 16, but not claim 18. Petitioner has introduced persuasive evidence that a skilled artisan would have had reasons to combine the teachings of Rosener and Huddart with a reasonable expectation of success. We have considered Patent Owner's arguments and evidence of objective indicia of nonobviousness, but do not find it persuasive, for the reasons explained above. In sum, upon consideration of all the evidence, we conclude that Petitioner has proved by a preponderance of the evidence that claims 1, 2, and 16 would have been obvious over Rosener and Huddart. Petitioner has not proved, by a preponderance of the evidence, that claim 18 would have been obvious over Rosener and Huddart.

C. Obviousness of Claims 3 and 4 over Rosener, Huddart, and Haupt

Petitioner contends that claims 3 and 4 would have been obvious over Rosener, Huddart, and Haupt. Pet. 57–64. Patent Owner does not challenge Petitioner's additional allegations for claims 3 and 4.

Haupt describes techniques for downloading digital data (e.g., MP3 music files) from the Internet using a computer (e.g., a PDA or notebook computer wirelessly connected to a network) and distributing those digital data to wireless headphones. Ex. 1006, 1.

Claim 3 depends from claim 1 and adds "wherein the processor circuit for the first earphone is for, upon activation of a user control of the headphones, initiating transmission of a request to a remote network server that is remote from the headphones." Claim 4 depends from claim 3 and adds "wherein the processor circuit of the first earphone is further for receiving a response to the request."

As we find above, Rosner teaches a processor circuit, for example broadband processor 914, signal conditioning circuits 916, 920, and other processing circuitry. Ex. 1003 ¶ 114. Petitioner contends that Haupt teaches activation of a user control of headphones and corresponding transmission of a request to a remote network server, after which the server sends, and the headphones receive, a response (e.g., downloaded audio content). Pet. 61–64. In particular, Petitioner cites to Haupt's description of interacting with control buttons on wireless headphones to connect with a server and retrieve audio files over a network. *Id.* (citing Ex. 1006, 2–5, 10–14, 21). Petitioner, relying on Dr. Cooperstock's testimony, contends that a skilled artisan would have combined Haupt's teachings with those of Rosener and Huddart to "improve[] performance when streaming data streams with high throughput requirements due to the increased data transmission rates,"

"impart[] new and useful functionality to [Rosener's] earphones 502, 504 as audio playback devices," and "provid[e] Internet access to the headphones." *Id.* at 58–61 (citing Ex. 1003 ¶¶ 57–61). We credit Dr. Cooperstock's uncontroverted testimony on this point.

Based on the evidence presented in the Petition, we find that the combination of Rosener, Huddart, and Haupt teaches each limitation of claims 3 and 4. Petitioner has introduced persuasive evidence that a skilled artisan would have had reasons to combine the teachings of Rosener, Huddart, and Haupt with a reasonable expectation of success. We have considered Patent Owner's arguments and evidence of objective indicia of nonobviousness, but do not find it persuasive, for the reasons explained above. In sum, upon consideration of all the evidence, we conclude that Petitioner has proved by a preponderance of the evidence that claims 3 and 4 would have been obvious over Rosener, Huddart, and Haupt.

D. Obviousness of Claims 9, 10, and 14 over Rosener, Huddart, and Price

Petitioner contends that claims 9, 10, and 14 would have been obvious over Rosener, Huddart, and Price. Pet. 65–71. Patent Owner disputes whether claims 9 and 10 would have been obvious, but does not contest Petitioner's allegations for claim 14. We find that the combination of Rosener, Huddart, and Price teaches each limitation of claims 9, 10, and 14.

Price "relates generally to collecting data from, sending data to, and/or updating software or digital data in electronic devices." Ex. 1008 ¶ 3. In one example, updated software code (including firmware) is retrieved by a computer from a data store on a network and delivered (wirelessly) to an electronic device. *Id.* ¶¶ 29, 38–39, Fig. 1. Exemplary electronic devices

include personal computers, digital cameras, TiVo-like devices, and personal digital assistants (such as Palm and Pocket PC devices). *Id.* ¶¶ 25, 33.

Claim 9 depends from claim 1 and adds "the processor circuits of the headphones are configured to receive firmware upgrades transmitted from a remote network server." Claim 10 depends from claim 9 and adds "wherein the headphone[s] are configured to receive the firmware upgrades wirelessly."

As to claims 9 and 10, Petitioner contends that Price teaches a coordinating computer obtaining software update code representing firmware upgrades from a server and transmitting those firmware upgrades to devices wirelessly. Pet. 69–71 (citing Ex. 1008 ¶¶ 26, 30, 33, 37, 38). According to Petitioner, a skilled artisan would have modified Rosener's transceiver 900 to implement processing related to the receipt of software update code for firmware upgrades, per the teachings of Price. *Id.* at 70 (citing Ex. 1003 ¶ 124). Petitioner argues that this feature of Price would have "provided the benefits of improving reliability, functionality, or compatibility" to Rosener's earphones. *Id.* at 70 (citing Ex. 1008 ¶¶ 5, 11; Ex. 1003 ¶¶ 124, 125).

In arguments similar to those presented for claim 18, discussed above, Patent Owner contends that "a [person of ordinary skill in the art] would not have attempted to use a low-power, pocket-charger-rechargeable battery as in Huddart, with wireless earphones that have the additional power consumption associated with receiving firmware upgrades, including wirelessly with respect to claim 10." PO Resp. 32–33 (citing Ex. 2035 ¶ 65). Here, Patent Owner mischaracterizes Petitioner's obviousness allegations as bodily incorporating Huddart's rechargeable battery into Rosener's earphone. *See also id.* at 34–35 ("As with dependent claim 18,

. . . the Petition and Cooperstock rely on Huddart's low-power earbud battery as a motivation to power the firmware-receiving earphones of claims 9 and 10. . . . Put another way, to the extent that a [person of ordinary skill in the art] might be motivated to power Rosener's earphone with Huddart's low-power, pocket-charger-rechargeable battery, neither Petitioner nor Cooperstock revisited whether the [person of ordinary skill in the art] would be motivated to use a rechargeable battery, like Huddart's low-power, pocket-charger-rechargeable battery, in a wireless headphone that additionally receives firmware upgrades (including wirelessly).”); Reply 28 n.3 (“[Patent Owner] misinterprets the Petition as incorporating Huddart's battery into Rosener”). This argument is unpersuasive, as Patent Owner's attempt to recast Petitioner's argument as a physical substitution of elements fails to take into account the teachings of Rosener and Huddart. *See Mouttet*, 686 F.3d at 1332–33.

Patent Owner further argues that “updating a device's firmware requires that the device be sufficiently powered throughout the firmware upgrade process,” and that “[o]ften, if the device loses power during the firmware upgrade process, the device can become inoperable (a so-called ‘brick').” PO Resp. 33. Patent Owner then argues that the '325 patent's solution is to implement the transceiver circuit on a single integrated circuit (IT), which it refers to as system-on-chip (SoC or SOC), implying that a SoC design is required by the patent's claims. *Id.* at 35–36 (citing Ex. 1001, 6:45–49; Ex. 2035 ¶¶ 70–71); *see also* Sur-reply 17–18 (“[T]the [Patent Owner Response's] description of the SOC described in the '325 Patent demonstrates how the '325 Patent enables a wireless earphone with a rechargeable battery to receive firmware upgrades.”). According to Patent Owner, without a teaching of “an earphone with a SoC for reduced power

consumption," a person of ordinary skill in the art "would realize that for claims 9 and 10, the battery would need to power non-SOC wireless earphones throughout the firmware update process; and if the battery ran out of power, the wireless earphones likely would become 'bricked.'" PO Resp. 35–36. Patent Owner concludes:

> If a [person of ordinary skill in the art] were truly motivated to use small, low-power rechargeable batteries in Rosener, the [person of ordinary skill in the art] would want to keep power requirements low by implementing lower power receiver technologies (like magnetic inductance or Bluetooth), and not additionally burdening the low power rechargeable battery with having to power the wireless device throughout a firmware update.

Id. at 36–37 (citing Ex. 2035 ¶ 72).

Petitioner faults Patent Owner for not presenting evidence showing that firmware upgrades involve significant power consumption. Reply 27. In any case, Petitioner argues, a skilled artisan would have known how to implement a Rosner-Huddart-Price combination in a way that does not require high power consumption, such as incrementally upgrading firmware. *Id.* at 29–30 (citing Ex. 1023 ¶¶ 50–51). In its Sur-reply, Patent Owner changes its argument, contending instead that it is the reliability of the

battery, rather than its power, that poses the risk of a device "becoming a brick." Sur-reply 17.[11]

Patent Owner's arguments are unpersuasive. First, as Petitioner argues (Reply 28), Patent Owner points to no persuasive evidence that the claims of the '325 patent require a SoC design for a transceiver. Mr. McAlexander's testimony, which merely copies the Patent Owner Response without identifying any basis for the testimony, is of little value. Ex. 2035 ¶¶ 70–72. Moreover, the '325 patent makes clear that a SoC design is only an example. Ex. 1001, 1001, 6:45–49 ("In various embodiments, the transceiver circuit 100 may be implemented as a single integrated circuit (IC), such as a system-on-chip (SoC), which is conducive to miniaturizing the components of the earphone 10, which is advantageous if the earphone 10 is to be relatively small in size.").

Second, Patent Owner's argument that the power source must be high-power or reliable assumes that the battery would be used for the entire firmware upgrade process, including both receiving the firmware update and installing it. PO Resp. 33. Claim 9 only recites a processor circuit "configured to receive firmware upgrades," and says nothing about installing firmware. Patent Owner provides no persuasive argument or evidence suggesting that a high-power or more reliable battery would be necessary to

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[11] Patent Owner repeatedly argued in its Response that it was the "low-power" nature of Huddart's battery that made it unsuitable for firmware upgrades. PO Resp. 32–37. Patent Owner's mention of an "unreliable power source" was in the context of Huddart's battery being low power. *Id.* at 37; *see also id.* at 30 (arguing that Huddart's "low-power battery" would be "unreliable" "due to its small capacity"). We decline to consider Patent Owner's new argument that Huddart's battery would have been unreliable. However, even if we did, it would not be persuasive, as we explain.

receive firmware, or that a power failure while receiving firmware (as opposed to a power failure during installation of the firmware) would result in "bricking" a device. Moreover, as Petitioner argues, a skilled artisan could have implemented the combination such that the firmware installation takes place while the earphone is connected to a charger, such as described in Huddart (primary charger and pocket charger). Reply 30–31 (citing Ex. 1023 ¶¶ 52–53; Ex. 1005, 8:28–34). Thus, even if firmware installation were required by claims 9 and 10, Patent Owner's argument still would be unpersuasive.

As explained for claims 1 and 18 (Sections II.B.3.b) and II.B.6 above), we find that a skilled artisan would have had persuasive reasons to incorporate Huddart's teaching of rechargeable batteries into Rosener's earphones, would have selected a rechargeable battery sufficient to power Rosener's circuitry (including transceiver 900, which would receive firmware upgrades), and would have had a reasonable expectation of success in doing so.

Claim 14 depends from claim 10, but otherwise adds limitations that are substantially the same as those added by claim 2. Petitioner incorporates by reference its arguments and evidence for claim 2. Pet. 71. As explained in Section II.B.4 above, we find that Rosener teaches each additional limitation of claim 2. For the same reasons, Rosener teaches each additional limitation of claim 14.

In conclusion, the combination of Rosener, Huddart, and Price teaches each limitation of claims 9, 10, and 14. Petitioner has introduced persuasive evidence that a skilled artisan would have had reasons to combine the teachings of Rosener, Huddart, and Price with a reasonable expectation of success. We have considered Patent Owner's arguments and evidence of

objective indicia of nonobviousness, but do not find it persuasive, for the reasons explained above. In sum, upon consideration of all the evidence, we conclude that Petitioner has proved by a preponderance of the evidence that claims 9, 10, and 14 would have been obvious over Rosener, Huddart, and Price.

E. Obviousness of Claim 15 over Rosener, Huddart, and Paulson

Petitioner contends that claim 15 would have been obvious over Rosener, Huddart, and Paulson. Pet. 71–75. Patent Owner does not contest Petitioner's additional allegations for claim 15.

Paulson describes a voice communication device, such as an earphone assembly with an ear tip that inserts in the ear canal and a microphone attached at the end of a boom. Ex. 1009, 5:1–8, Figs. 1A, 1B, 2. In one example, Paulson describes a push-button switch that can be pushed to enable and mute the microphone. *Id.* at 6:18–49.

Claim 15 depends from claim 1 and adds

> wherein the processor circuit of the first earphone is configured to:
>
> > process audible utterances by the user picked by the microphone in response to activation of the microphone by the user; and
> >
> > transmit a communication based on the audible utterances via the Bluetooth wireless communication links.

Petitioner argues that Paulson's unmute feature corresponds to enabling a microphone and processor circuit to "process audible utterances by the user picked by the microphone in response to activation of the microphone by the user," as recited in claim 15. Pet. 73–74 (citing Ex. 1009, 6:18–49). Petitioner cites Rosener for the ability to "transmit a

communication based on the audible utterances via the Bluetooth wireless communication links," as recited in claim 15. *Id.* at 74–75 (citing Ex. 1004 ¶¶ 11, 35, 49, 56). According to Petitioner and Dr. Cooperstock (Pet. 73; Ex. 1003 ¶ 71), a skilled artisan would have combined Paulson's and Rosener's features in light of Paulson's statements that its "feature is important for users in a noisy environment, to allow them to reduce the noise heard by the distant party." Ex. 1009, 6:33–35. We credit Dr. Cooperstock's uncontested testimony on this point.

In light of Petitioner's evidence, we find that the combination of Rosener, Huddart, and Paulson teaches each limitation of claim 15. Petitioner has introduced persuasive evidence, including Dr. Cooperstock's testimony, that a skilled artisan would have had reasons to combine the teachings of Rosener, Huddart, and Price with a reasonable expectation of success. We have considered Patent Owner's arguments and evidence of objective indicia of nonobviousness, but do not find them persuasive for the reasons explained above. In sum, upon consideration of all the evidence, we conclude that Petitioner has proved by a preponderance of the evidence that claim 15 would have been obvious over Rosener, Huddart, and Paulson.

F. Obviousness of Claims 16 and 17 over Rosener, Huddart, and Vanderelli

Petitioner contends that claims 16 and 17 would have been obvious over Rosener, Huddart, and Vanderelli. Pet. 75–78. Patent Owner does not contest Petitioner's additional allegations for this ground.

Vandereilli describes a wireless power supply that rectifies RF energy and stores it in a group of capacitors. Ex. 1010, Abstract, 2:1–51, 4:9–17, Fig. 1.

For claim 16, Petitioner cites Vanderelli for additional examples, beyond those shown in Huddart, of "wirelessly chargeable circuit components." Pet. 77. As explained above, we conclude that claim 16 would have been obvious over Rosener and Huddart. Thus, we do not reach whether claim 16 also would have been obvious over Rosener, Huddart, and Vanderelli. *See SAS*, 138 S. Ct. at 1359); *Bos. Sci. Scimed*, 809 F. App'x at 990.

As to claim 17, Petitioner contends that a "passive, wireless rechargeable power source" is a rechargeable power source that "may comprise capacitors passively charged with RF radiation." Pet. 51 (quoting Ex. 1001, 7:3–5; citing Ex. 1003 ¶ 104), 78 (quoting Ex. 1001, 7:3–5; citing Ex. 1003 ¶ 134). Petitioner contends that a skilled artisan would have incorporated Vanderelli's technique of rectifying RF energy and storing it in capacitors because it would have provided the "advantages of obtaining energy from a range of RF frequencies." *Id.* at 78 (citing Ex. 1003 ¶ 134). We credit Petitioner's evidence, including Dr. Cooperstock's uncontested testimony.

In light of Petitioner's evidence, we find that the combination of Rosener, Huddart, and Vanderelli teaches each limitation of claim 17. Petitioner has introduced persuasive evidence, including Dr. Cooperstock's testimony, that a skilled artisan would have had reasons to combine the teachings of Rosener, Huddart, and Vanderelli with a reasonable expectation of success. We have considered Patent Owner's arguments and evidence of objective indicia of nonobviousness, but do not find it persuasive, for the reasons explained above. In sum, upon consideration of all the evidence, we conclude that Petitioner has proved by a preponderance of the evidence that claim 17 would have been obvious over Rosener, Huddart, and Vanderelli.

III. CONCLUSION[12]

Petitioner has shown by a preponderance of the evidence that claims 1–4, 9, 10, and 14–17 would have been obvious. Petitioner has not shown by a preponderance of the evidence that claim 18 would have been obvious.

In summary:[13]

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 2, 16–18	103(a)	Rosener, Huddart	1, 2, 16	18
3, 4	103(a)	Rosener, Huddart, Haupt	3, 4	
9, 10, 14	103(a)	Rosener, Huddart, Price	9, 10, 14	
15	103(a)	Rosener, Huddart, Paulson	15	
16, 17	103(a)	Rosener, Huddart, Vanderelli	17	
Overall Outcome			1–4, 9, 10, 14–17	18

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[12] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. *See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

[13] For the reasons explained above, we do not reach whether claim 17 would have been obvious over Rosener and Huddart, or whether claim 16 would have been obvious over Rosener, Huddart, and Vanderelli.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED, based on a preponderance of the evidence, that claims 1–4, 9, 10, and 14–17 have been shown to be unpatentable;

FURTHER ORDERED, based on a preponderance of the evidence, that claim 18 has not been shown to be unpatentable; and

FURTHER ORDERED, because this is a final written decision, the parties to this proceeding seeking judicial review of our Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper 43
Date: June 27, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE, INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

IPR2021-00381
Patent 10,491,982 B1

Before DAVID C. McKONE, GREGG I. ANDERSON, and
NORMAN H. BEAMER, *Administrative Patent Judges*.

ANDERSON, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining Some Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Apple, Inc. ("Petitioner") filed a Petition requesting *inter partes* review of claims 1–5 and 14–20 of U.S. Patent No. 10,491,982 (Ex. 1001, "the '982 patent"). Paper 2 ("Pet."). Koss Corporation ("Patent Owner") filed a Preliminary Response. Paper 10 ("Prelim. Resp."). Upon our authorization, Petitioner filed a Preliminary Reply relating to discretionary denial based on the factors set forth in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential). Paper 11 ("Prelim. Reply"). Patent Owner filed a Preliminary Sur-Reply. Paper 12 ("Prelim. Sur-Reply"). We instituted *inter partes* review on July 2, 2021. Paper 15 ("Inst. Dec."). Patent Owner filed a Response (Paper 19, "PO Resp."), Petitioner filed a Reply (Paper 31, "Reply"), and Patent Owner filed a Sur-Reply (Paper 34, "Sur-Reply"). A hearing was held on April 5, 2022, and a transcript has been made of record. Paper 42 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This Decision is a final written decision under 35 U.S.C. § 318(a) as to the patentability of claims 1– 5 and 14–20. Based on the record before us, Petitioner has proved, by a preponderance of the evidence, that claims 1–5 and 14–18 are unpatentable, but has not proved that claims 19 and 20 are unpatentable.

II. BACKGROUND

A. Real Parties in Interest

Petitioner states it is the real party-in-interest. Pet. 85. Patent Owner states it is the real party-in-interest. Paper 4 ("Mandatory Notice by Patent Owner"), 1; *see also* Papers 6–9 (Updates to Mandatory Notice).

B. Related Matters

Both parties list a related lawsuit alleging infringement of the ’982 patent, *Koss Corporation v. Apple Inc.*, Case No. 6:20-cv-00665 (W.D. Tex.) (“District Court Lawsuit”). Pet. 86. Patent Owner lists the District Court Lawsuit and other lawsuits involving the ’982 patent, United States applications to which the ’982 patent claims priority, and pending *inter partes* reviews as Related Matters. Paper 9, 1–2.

1. Other Lawsuits

Patent Owner identifies five other lawsuits involving the ’982 patent: *Koss Corporation v. PEAG LLC d/b/a JLab Audio*, Case No. 6:20-cv-00662 (W.D. Tex.); *Koss Corporation v. Skullcandy, Inc.*, Case No. 6:20-cv-00664 (W.D. Tex); *Apple Inc. v. Koss Corporation*, Case No. 4:20-cv-05504 (N.D. Cal.); *Koss Corporation v. Apple Inc.*, Case No. 6-20-cv-00665 (W.D. Tex.); and *Koss Corporation v. Skullcandy, Inc.*, Case No. 2:21-cv-00203 (D. Utah). Paper 9, 1.

2. United States Applications

Patent Owner lists the following as Related Applications to which the ’982 patent claims priority: PCT application No. PCT/US2009/039754, filed April 7, 2009 (the “PCT Application”) and provisional application Serial No. 61/123,265, filed April 8, 2008 (the “Provisional Application”). Paper 9, 1.

3. *Inter Partes Review Proceedings*

Patent Owner lists the following *inter partes* review proceedings[1] challenging patents that claim priority to the PCT Application and the Provisional Application:

Bose Corporation v. Koss Corporation, IPR2021-00297, filed December 7, 2020, challenging US Patent 10,368,155 B2;

Apple Inc. v. Koss Corporation, IPR2021-00305, filed December 15, 2020, challenging US Patent 10,506,325 B1;

Apple Inc. v. Koss Corporation, IPR2021-00546, filed February 22, 2021, challenging US Patent 10,206,025 B2;

Apple Inc. v. Koss Corporation, IPR2021-00592, filed March 2, 2021, challenging US Patent 10,469,934 B2;

Apple Inc. v. Koss Corporation, IPR2021-00612, filed March 3, 2021, challenging U.S. Patent 10,206,025;

Apple Inc. v. Koss Corporation, IPR2021-00626, filed March 17, 2021, challenging US Patent 10,206,025 B2;

Bose Corporation v. Koss Corporation, IPR2021-00680, filed March 17, 2021, challenging US Patent 10,469,934 B2;

Apple Inc. v. Koss Corporation, IPR2021-00679, filed March 22, 2021, challenging US Patent 10,506,325 B1; and

[1] *Apple Inc. v. Koss Corporation*, IPR2021-00255, filed November 25, 2020, and *Apple Inc. v. Koss Corporation*, IPR2021-00600, filed March 7, 2021, both challenging US Patent 10,298,451 B1, and *Apple Inc. v. Koss Corporation*, IPR2021-00686, filed March 22, 2021, challenging US Patent 10,491,982 B1, are also pending *inter partes* reviews between these same parties.

Apple Inc. v. Koss Corporation, IPR2021-00693, filed March 23, 2021, challenging US Patent 10,469,934 B2.

Paper 9. 1–2.

C. The '982 Patent

The application for the '982 patent's earliest priority dates are April 7, 2009, to the PCT Application and April 8, 2008[2], to the Provisional Application. Ex. 1001, codes (60), (63). See Section II.B.2 above.

1. Background Technology

The '982 patent explains that wired headphones interconnecting headphones and a data storage unit are "cumbersome." Ex. 1001, 1:56–59. "Recently, cordless headphones that connect wirelessly via IEEE 802.11 to a WLAN-ready laptop or personal computer (PC) have been proposed, but "such headphones are also quite large and not in-ear type phones." *Id.* at 1:66–2:4.

2. The '982 Patent's Wireless Earphones

The '982 patent describes and claims "a wireless earphone that receives streaming audio data via ad hoc wireless networks and infrastructure wireless networks, and that transitions seamlessly between wireless networks." Ex. 1001, 2:64–66. "[T]he earphone may transition automatically from an ad hoc wireless network to an infrastructure wireless network, without user intervention." *Id*. at 3:8–11. The '982 patent defines "ad hoc wireless network" as "a network where two . . . wireless-capable devices, such as the earphone and a data source, communicate directly and wirelessly, without using an access point." *Id.* at 3:8–14. The '982 patent defines "infrastructure wireless network" as "a wireless network that uses

[2] The priority date is not in dispute. See Pet. 2.

one or more access points to allow a wireless-capable device, such as the wireless earphone, to connect to a computer network, such as a LAN or WAN (including the Internet).” *Id*. at 3:14–19.

Two discrete wireless earphones are described, each having a body and an “ear canal portion for insertion into the canal of the user of the earphone.” *Id.* at 3:25–27, 3:54–56. Figure 2A of the ’982 patent is reproduced below.

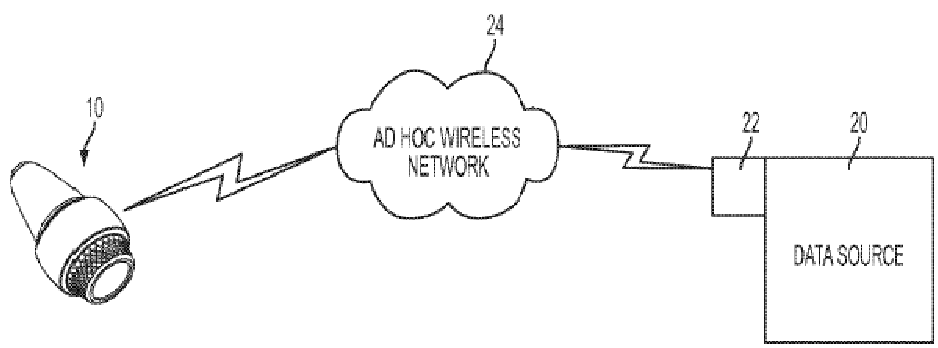

FIG. 2A

Figure 2A illustrates one of the communication modes for the wireless earphone.

Ex. 1001, 2:36–38. Figure 2A illustrates a wireless network adapter 22 connected to a data source 20 in communication with earphone 10 over ad hoc wireless network 24. *Id.* at 4:33–37. The earphone has a transceiver circuit to communicate wirelessly with a data source. *Id.* at 4:35–37. The data source may be a digital audio player (DAP). *Id.* at 4:39–40. The DAP transmits audio wirelessly to earphone(s) via an ad hoc network if the DAP and earphone(s) are “in range” of that network. *Id.* at 4:63–65. “When in range, the data source 20 may communicate with the earphone 10 via the ad

hoc wireless network 24 using any suitable wireless communication protocol, including Wi-Fi (e.g., IEEE 802.lla/b/g/n), WiMAX (IEEE 802.16), Bluetooth" and other communication protocols. *Id.* at 4:63–5:1.

Figure 2B of the '982 patent is reproduced below.

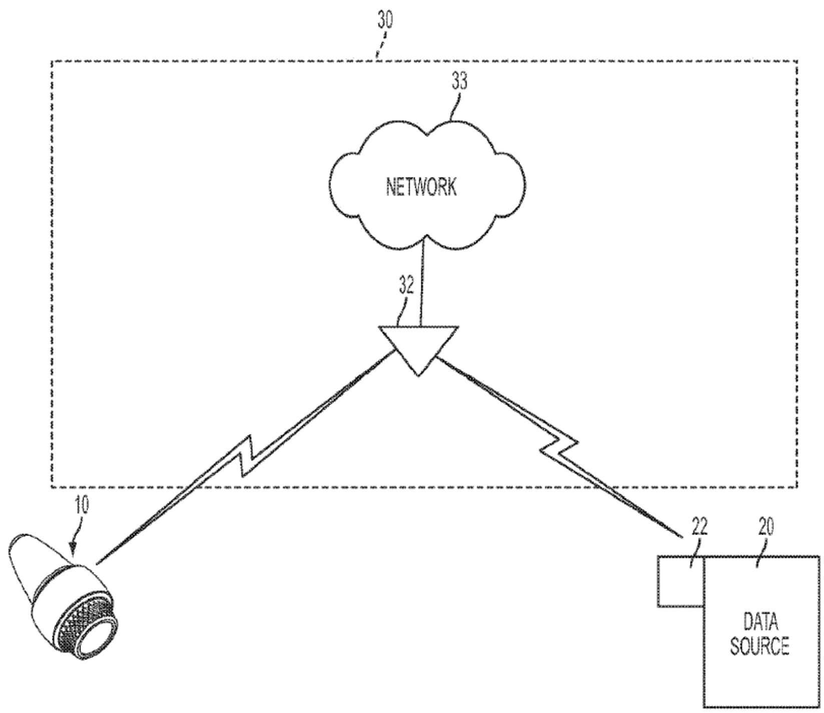

FIG. 2B

Figure 2B illustrates another of the communication modes for the wireless earphone.

Ex. 1001, 2:36–38. The data source and wireless network adapter may transmit digital audio wirelessly through an access point 32 over "an infrastructure wireless network (such as a wireless LAN (WLAN) 30". *Id.* at 4:34–40. "[T]he wireless network adapter 22 may comprise a wireless network interface card (WNIC) or other suitable transceiver that plugs into a USB port or other port or jack of the data source 20 (such as a TRS connector) to stream data, e.g., digital audio files, via a wireless network

(e.g., the ad hoc wireless network 24 or an infrastructure wireless network).” *Id*. at 4:50–56.

D. Illustrative Claim

Claims 1–5 and 14–20 of the ’982 patent are challenged. Pet. 1–2, 18–85. Claim 1 is the only independent claim challenged. Claims 2–5 and 14–20 depend directly or indirectly from claim 1. All claims are directed to a “system.” Claim 1 is reproduced below as illustrative.

> [1.P][3] 1. A system comprising:
>
> [1.a] headphones comprising a pair of first and second wireless earphones to be worn simultaneously by a user,
>
> [1.b] wherein the first and second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected,
>
> [1.c] wherein each of the first and second earphones comprises:
>
> > [1.c.i] a body portion that comprises:
> >
> > > [1.c.i.A] a wireless communication circuit for receiving and transmitting wireless signals;
> > >
> > > [1.c.i.B] a processor circuit in communication with the wireless communication circuit; and
> > >
> > > [1.c.i.C] an ear canal portion that is inserted into an ear of the user when worn by the user; and

---

[3] For purposes of this Decision, we follow Petitioner’s format where each claim is identified by claim number followed by a letter or combination of letters and Roman numerals for each limitation. *See* Pet. 32–53 (limitations 1.P– 1.d).

[1.c.i.D] at least one acoustic transducer connected to the processor circuit; and

[1.c.ii] an elongated portion[4] that extends away from the body portion such that the elongated portion extends downwardly when the ear canal portion is inserted in the ear of the user;

[1.c.iii] a microphone connected to the processor circuit and for picking up utterances of a user of the headphones;

[1.c.iv] an antenna connected to the wireless communication circuit; and

[1.c.v] a rechargeable power source; and

[1.d] a mobile, digital audio player that stores digital audio content and that comprises a wireless transceiver for transmitting digital audio content to the headphones via Bluetooth wireless communication links, such that each earphone receives and plays audio content received wirelessly via the Bluetooth wireless communication links from the mobile, digital audio player.

Ex. 1001, 18:8–40.

E. Evidence of Record

This proceeding relies on the following prior art references and expert testimony:

Rosener, US 2008/0076489 A1, published Mar. 27, 2008 (Ex. 1004);

[4] This limitation recites "elongated portion," which does not appear in the Specification.

Hankey, US 2008/166001 A1, published July 10, 2008 (Ex. 1005);

Dyer, US 8,031,900 B2, issued Oct. 4, 2001 (Ex. 1006);

Huddart, US 7,627,289 B2, issued Dec. 1, 2009 (Ex. 1007);

Hankey Provisional,[5] US 60/879,177, filed Jan. 6, 2007 (Ex. 1008);

Price, US 2006/0026304 A1, published Feb. 2, 2006 (Ex. 1009);

Paulson, US 7,551,940 B2, issued June 23, 2009 (Ex. 1010);

Marek, US 5,371,454, issued Dec. 6, 1994 (Ex. 1011);

Vanderelli, US 7,027,311 B2, issued Apr. 11, 2006 (Ex. 1012); and

Haupt, EP 2006/042749 A2, issued Apr. 27, 2006 (Ex. 1020, including English translation).

Petitioner also relies on the Declaration of Dr. Jeremy Cooperstock (Ex. 1003, "Cooperstock Declaration") and the Supplemental Declaration of Dr. Jeremy Cooperstock (Ex. 1024, "Cooperstock Supplemental Declaration").

Patent Owner relies on the Declaration of Joseph C. McAlexander III (Ex. 2038, "McAlexander Declaration") and the Declaration of Nicholas S. Blair (Ex. 2039, "Blair Declaration").

F. Prior Art and Asserted Grounds

Petitioner asserts that claims 1–5 and 14–20 would have been unpatentable on the following grounds (Pet. 1–2, 18–85):

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[5] Hankey Provisional is a US provisional application related to Hankey. *See* Ex. 1005 code (60).

Claim(s) Challenged	35 U.S.C. §[6]	Reference(s)/Basis
1, 2, 18–20	103	Rosener, Hankey or Rosener, Hankey, Dyer
3–5	103	Rosener, Hankey, Haupt or Rosener, Hankey, Dyer, Haupt
14	103	Rosener, Hankey, Price or Rosener, Hankey, Dyer, Price
15	103	Rosener, Hankey, Paulson or Rosener, Hankey, Dyer, Paulson
16–17	103	Rosener, Hankey, Huddart or Rosener, Hankey, Dyer, Huddart
17	103	Rosener, Hankey, Huddart, Vanderelli or Rosener, Hankey, Dyer, Huddart, Vanderelli

III. ANALYSIS

A. Level of Ordinary Skill in the Art

Petitioner's expert Dr. Cooperstock, testifies that, based on his experience and the references used to challenge the '982 patent, a person of ordinary skill in the art at the time of the critical date for the '982 patent

> would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks. Superior education could compensate for a deficiency in work experience, and vice-versa.

[6] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. §§ 102 and 103, effective March 16, 2013. Because the application that resulted in the '982 patent has an effective filing date before this date, the pre-AIA versions of §§ 102 and 103 apply.

Ex. 1003 ¶ 30. This level of skill was adopted in the Institution Decision. Inst. Dec. 33. Patent Owner agrees we "should maintain this standard for the proceeding as Patent Owner agrees that it is an appropriate standard." PO Resp. 5–6 (citing Ex. 2038 ¶ 20). At the Final Hearing, all parties agreed the above level of skill is the correct one for this proceeding. Tr. 73:1–74:13.

Dr. Cooperstock's proposal is consistent with the level of ordinary skill in the art reflected by the prior art. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001); *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995). As per the agreement of the parties, including their experts, and consistent with the prior art, we adopt the above level of ordinary skill for this Decision.

B. Claim Construction

The Petition was accorded a filing date of January 4, 2021. Paper 5. For petitions filed on or after November 13, 2018, a claim shall be construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent. 37 C.F.R. § 42.100 (2019). Thus, we apply the claim construction standard as set forth in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc).

Petitioner cites 37 C.F.R. § 42.100, asserts construction is unnecessary, and does not propose any term for express construction in the claim construction section of the Petition. Pet. 18. Notwithstanding the preceding, Petitioner raises a construction issue with respect to claim 17's

recitation of "passive, wireless rechargeable power source." Pet. 80–81. We preliminarily agreed with Petitioner's proposed construction and determined that a "passive" power source 102 "may comprise capacitors passively charged with RF radiation." Inst. Dec. 34 (citing Pet. 80–81 (quoting Ex. 1001, 7:7–9)[7]). Patent Owner does not dispute our preliminary construction or identify any other claim term for express construction. *See generally* PO Resp.

The papers filed since institution do not raise a dispute regarding "passive, wireless rechargeable power source." For completeness of the record, we maintain our preliminary construction of "passive, wireless rechargeable power source." We also determine construction is unnecessary for any other claim term in order to resolve the dispute. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy."). On all other claim terms we proceeded based on the plain and ordinary meaning as understood by a person of ordinary skill in the art. Inst. Dec. 34.

C. Legal Standard for Obviousness

A patent claim is invalid as obvious if the differences between the claimed subject matter and the prior art are "such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103(a).

> The ultimate determination of obviousness is a question of law, but that determination is based on underlying factual

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[7] The Cooperstock Declaration does not provide a construction for any claim term. *See* Ex. 1003 ¶ 29.

> findings. . . . The underlying factual findings include (1) "the scope and content of the prior art," (2) "differences between the prior art and the claims at issue," (3) "the level of ordinary skill in the pertinent art," and (4) the presence of secondary considerations of nonobviousness such "as commercial success, long felt but unsolved needs, failure of others," and unexpected results.

In re Nuvasive, Inc., 842 F.3d 1376, 1381 (Fed. Cir. 2016) (citing *inter alia*, *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966)).

"To satisfy its burden of proving obviousness, a petitioner cannot employ mere conclusory statements. The petitioner must instead articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016). Furthermore, in assessing the prior art, the Board must consider whether a person of ordinary skill would have been motivated to combine the prior art to achieve the claimed invention. *Nuvasive*, 842 F.3d at 1381.

As the Federal Circuit found, in quoting from the Supreme Court's decision in *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418–419 (2007),

> because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known," "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does."

Personal Web Technologies, LLC v. Apple, Inc., 848 F.3d 987, 991–92 (Fed. Cir. 2017).

D. Obviousness of Claims 1–2 and 18–20 over Rosener and Hankey or Rosener, Hankey, and Dyer[8]

Petitioner alleges claims 1–2 and 18–20 would have been obvious over Rosener and Hankey or Rosener, Hankey, and Dyer. Pet. 1, 18–58. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶¶ 16–57, 59–91.

1. Rosener (Ex. 1004)

Rosener relates to wireless communication between an external data or audio device, like a cell phone or PDA, MP3 or CD player, radio personal computer or game console, and first and second earphones. Ex. 1004 ¶¶ 1, 30. Rosener explains that conventional wireless earphones came in different designs, each with "its own unique benefits and drawbacks." *Id.* ¶¶ 5–10, Figs. 2–4. Rosener focuses on wireless "earbuds." *Id.* at Abs., ¶¶ 11, 30, Fig. 5.

Each earbud is designed to fit into the concha of the pinna of the user's ear, and includes a housing containing a speaker, a radio-frequency (RF) transceiver, and a battery. Ex. 1004 ¶ 30. The transceiver of each is "configured to receive data signals over one or more single-access wireless links or over a multi-access wireless link." *Id.* ¶ 11. The Bluetooth industrial specification (IEEE 802.15.1 standard) is one communication protocol disclosed that allows each of the earphones to communicate with the external data or audio data devices. *Id.* ¶¶ 4, 35.

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[8] We have analyzed commercial success for all challenges. See Section III.J below.

Figure 9, reproduced below, illustrates some of the components of Rosener's headphones:

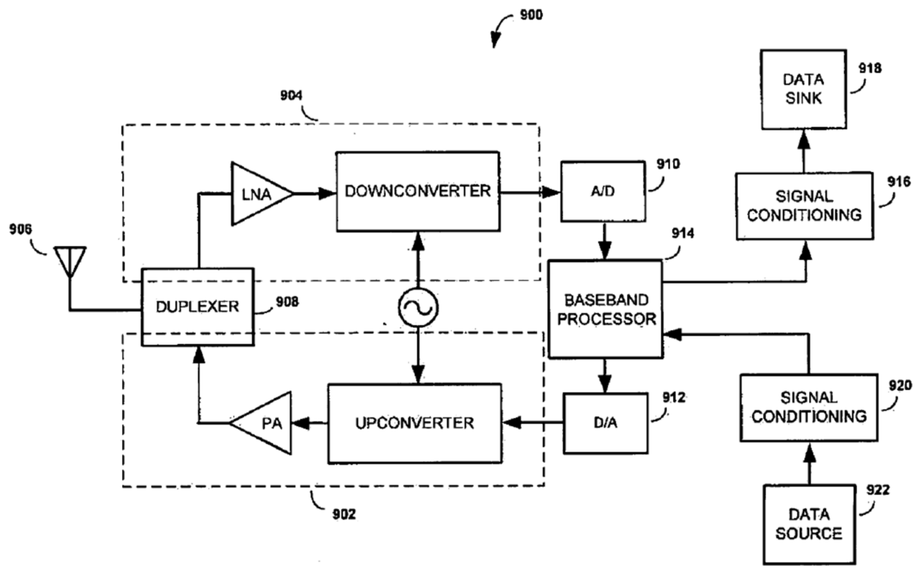

FIGURE 9

Figure 9 is a block diagram of an RF transceiver.

Ex. 1004 ¶¶ 24, 49. As shown above, RF transceiver 900 includes RF transmitter portion 902, RF receiver portion 904, antenna 906, and duplexer 908. *Id.* ¶ 49. A/D converter 910 receives analog baseband signals from RF transceiver portion 904, digitizes the signals, and sends them to baseband processor 914, which, along with signal conditioning circuit 916, processes the signals into a form suitable to drive data sink (speaker) 918. *Id.* Baseband processor 914 receives data from data source 922 (e.g., a microphone) via signal conditioning circuit 920 and provides the data to RF transmitter portion 902 for transmission via antenna 906. *Id.* 1650.

2. Hankey[9] (Ex. 1005)

Hankey describes a headset within "a small compact unit." Ex. 1005 ¶¶ 93, 103. The techniques disclosed in Hankey include integrating electronic components/assemblies (e.g., speaker, antenna) into the limited volume of a small headset, by dividing the headset's electronic components/assemblies "into small multiple [groups of] components that can be positioned at different locations (discretely) within the headset." *Id.* ¶ 98. Similarly, "electronic assemblies that are partially flexible or bendable such that the assemblies can be folded into a small compact form in order to fit inside tightly spaced internal volumes." *Id*. ¶ 99.

Hankey divides the headset's electronic components/assemblies between the earbud and the primary housing. Ex. 1005 ¶¶ 130–131. For example, the processor and speaker may be placed inside the earbud while the microphone "can be electrically coupled to primary housing flexible circuit board." *Id.* ¶ 131.

Figures 10A and 10B of Hankey are reproduced below.

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[9] In describing Hankey, Petitioner also cites to Ex. 1008, the Hankey Provisional. Pet. 21; Ex. 1005, code (60); Section II.E above. Petitioner cites to the Hankey Provisional to prove "Hankey is entitled to the benefit of its provisional filing date, *i.e.*, the January 6, 2007 filing date." Pet. 3 (quoting Ex. 1003 ¶ 43; citing Ex. 1008 ¶¶ 89–90, 208–212, Figs 1A, 40A, 41–44). We cite only to Hankey, not the Hankey Provisional. Patent Owner does not dispute that Hankey is prior art and we find the filing date of the Hankey Provisional is the priority date for Hankey.

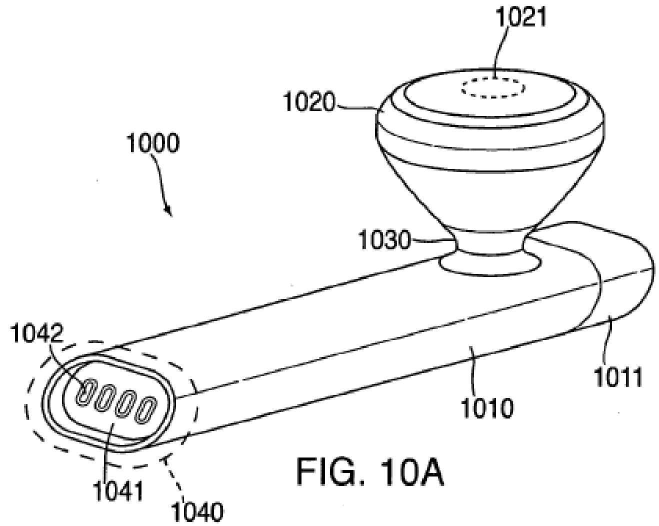


FIG. 10A

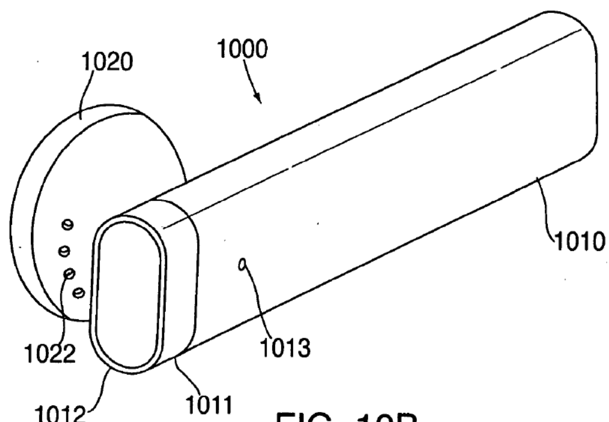


FIG. 10B

Figures l0A and 10B are perspective views of Hankey's headset.

Ex. 1005 ¶ 143. Figure 10A shows headset 1000 for enclosing "electronic and other elements of the headset." *Id.* ¶ 144. The headset "can include earbud 1020, neck 1030, primary housing 1010, antenna cap 1011 and connector 1040." *Id.* "Earbud 1020 can include perforations (e.g., acoustic ports) 1021 and 1022 for allowing air to pass into and out of the earbud 1020." *Id.* "Front port 1021 can allow sound waves from a receiver located in earbud 1020 to reach a user's ear and/or the outside environment." *Id.* Button 1012 can control the headset. *Id.* ¶ 145.

3. Dyer (Ex. 1006)

Dyer describes a "canalphone" type including an eartip that fits within a user's ear canal. Ex. 1006, 3:4–6, 4:37–39, Fig. 1. The eartip is "attachable to a standard generic earphone." *Id.* at 1:10–11, 2:21–24.

Dyer's Figure 1 is reproduced below.

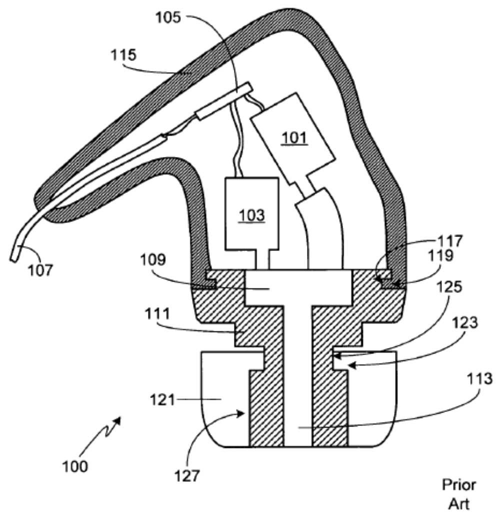


FIG. 1

Figure 1 is a cross-sectional view of a generic earphone in accordance with the prior art.

Ex. 1006, 2:48–49. Figure 1 illustrates an example of "canalphone" 100 that includes a sound delivery member 111 with an eartip 121 attached to an end portion of it. *Id.* at 3:4–6, 3:26–28, 4:4–14. Sound delivery member 111 is attached to earphone enclosure 115 that protects "any required earphone circuitry" of canalphone 100 from damage. *Id*. at 3:57–66. Intermediary member 111 includes a sound delivery tube 113 that delivers audio from circuitries in enclosure 115 to eartip 121. *Id.* at 3:22–25.

4. Claim 1

Patent Owner disputes that a person of ordinary skill, as determined above in Section III.A, would have had sufficient skill to combine Rosener and Hankey with a reasonable expectation of success. PO Resp. 12–21. Patent Owner disputes the reasons for combining Rosener, Hankey, and Dyer. *Id*. at 34–40. Patent Owner also disputes that the Rosener and Hankey or Rosener, Hankey, and Dyer combinations teach two wireless earphones, each having a microphone. *Id*. at 21–34.

a. Rosener and Hankey Reasons for the Combination and Expectation of Success

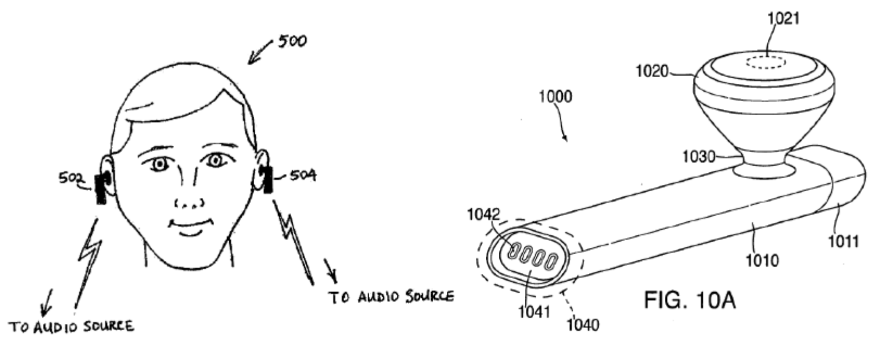
Petitioner's reasons for combining Rosener and Hankey start with Rosener's teaching of "providing 'high-quality stereo,' i.e., binaural, functionality." Pet. 24 (citing Ex. 1004 ¶¶ 30, 3–8, Fig. 5; Ex. 1003 ¶ 44). Petitioner relies on Rosener as teaching two "earpieces/earphones" 502 and 504 in wireless communication with an "audio source." *Id*. at 25 (citing Ex. 1004, Fig. 5; *see also id.* ¶ 30 (describing Fig. 5)). Petitioner relies on Hankey for details of the form factor for the earphones 502 and 505, thus implementing the combination of Rosener's earphones and Hankey's "small compact earpiece[s]."[10] Pet. 25–27 (citing Ex. 1003 ¶¶ 45, 47). Petitioner argues "Hankey considers the size and weight of prior art headsets as a 'key issue' that causes an uncomfortable fit of the headsets on a user's ear." *Id*. at 26 (citing Ex. 1005 ¶ 11; Ex. 1008[11] ¶ 3). Petitioner

[10] Hankey uses the term "headset" but Petitioner uses "earpiece" for "consistency and to avoid confusion." *See* Pet. 24, n.6. We find that convention reasonable and adopt it here.

[11] Sanford, US Provisional Application No. 60/879,177, filed Jan. 6, 2007 (Ex. 1008). Provisional application for Hankey. *See* Ex. 1005 code (60).

argues that "Hankey discloses a compact earpiece capable of communicating with external audio devices wirelessly." *Id.* (citing Pet. 22–23 (describing Hankey)).

Petitioner argues Hankey "provides techniques to package electronics within 'a small compact unit' to alleviate the size and shape hassles of conventional headsets." Pet. 26 (citing Ex. 1005 ¶¶ 92–98; Ex. 1008 ¶¶ 93, 144–150). Petitioner alleges a person of ordinary skill in the art would have been motivated to arrange the components of Hankey in a "small, compact form factor" as shown in Figure 5 of Rosener. *Id.* (citing Ex. 1003 ¶ 46). Petitioner provides a side-by-side comparison of Rosener's Figure 5 as compared to Hankey's Figure 10A, which is reproduced below.



Petitioners compare shows Rosener's Figure 5 on the left and Hankey's Figure 10A on the right.

Pet. 27. Petitioner alleges a person of ordinary skill in the art "would have recognized the similarities between the earpieces shown in Hankey's FIGs. 5 or 10A and earphones 502, 504 shown in Rosener's FIG. 5, and would have been motivated to use Hankey's component arrangement techniques to implement internal components and external features of earphones 502, 504." *Id.* at 27–28 (citing Ex. 1003 ¶ 48).

Petitioner alleges Rosener's earphones 502, 504 are "physically and electrically" separate and a person of ordinary skill in the art "would have

recognized that Hankey's techniques are readily applicable to Rosener's earphones 502, 504." Pet. 28 (citing Ex. 1004 ¶ 30). Dr. Cooperstock is relied on for his testimony that latency compensation processing would "enable stereo play when both earphones are being simultaneously used." *Id*. at 28–29 (citing Ex. 1004 ¶¶ 11, 39–42; Ex. 1003 ¶ 49).

We find that Petitioner has shown sufficiently that a person of ordinary skill in the art would have had reason to combine Hankey's "small form factors" with Rosener's earphones. Pet. 25–29. Patent Owner argues stereo input by the microphones to the earphones is an insufficient reason for the combination and the Cooperstock Deposition testimony supporting it is speculative. PO Resp. 32 (citing Ex. 2037, 104:12–18). Mr. McAlexander testifies Rosener is intended for "communication purposes" and not music. Ex. 2038 ¶ 71. Mr. McAlexander testifies that Rosener and Hankey would be for communication and not "capturing high-quality, stereo audio recordings." Ex. 2038 ¶ 71; *see also* PO Resp. 32–33 (making same argument).

Patent Owner also argues a second microphone (see Section III.D.4.c below, analyzing the "microphone limitation") would "add significant complexity" to the combination. PO Resp. 33 (citing Ex. 2038 ¶ 73). The argument is based on the earphones being physically spaced apart, along with the associated microphone, resulting in different signal strengths. *Id*. at 34 (citing Ex. 2038 ¶ 74). Thus, there is a need to determine which signal is stronger for communication with the external device. *Id*. at 33–34 (citing Ex. 2038 ¶ 74). According to Patent Owner, the need to accommodate the difference in signal strength requires additional signal processing and complexity. *Id*. at 34 (citing Ex. 2038 ¶ 74). Patent Owner

concludes by arguing a person of ordinary skill in the art "would not modify the Rosener-Hankey combination (or Rosener-Hankey-Dyer combination) to include a microphone in each earphone." *Id*. (emphasis omitted).

We adopt as our findings Petitioner's argument and evidence summarized above. We find that the addition of stereo audio reception is a reason to combine Hankey with Rosener. Rosener discloses "high quality stereo sound" with two separate earpieces/earphones. Ex. 1004 ¶¶ 10–11 ("left-ear and right-ear circum-aural over-the-ear headphones, stereo speakers, speakers for a surround sound system, etc."). "[H]igh-quality stereo sound" is an advantage over the prior art in "allowing each of the two earpieces/earphones to be 'physically and electrically separated' from the other." Ex. 1003 ¶ 44 n.2 (citing Ex. 1004 ¶¶ 10–11).

The McAlexander testimony that Rosener's microphone would be understood by a person of ordinary skill in the art as intended "exclusively for communication purposes," and not "stereo audio recordings," is not persuasive. Ex. 2038 ¶ 71. Why the alleged distinction makes a difference is not explained. The '982 patent does not discuss the difference in the context of the written description nor is it part of any claim. Indeed, Mr. McAlexander points to recent smartphone products, not the '982 patent, for their teachings of "using multiple microphones." *Id*. (examples including Apple XSW and XR).

In connection with the challenge to claim 1 based on Rosener and Hankey or Rosener, Hankey, and Dyer (this combination is analyzed in Section III.D.4.b below), Patent Owner makes several arguments that a person of ordinary skill would not have a level of skill sufficient to combine the references as Petitioner proposes. PO Resp. 1, 12–21; *see also* Pet. 24–

31 (reasons for the combination). More specifically, Patent Owner argues that Dr. Cooperstock's "experience [is] superior" to a person of ordinary skill in the art yet he does not understand the operation of the prior art, highlighting the "complexity of designing wireless earphones." PO Resp. 1; *see also id*. at 14–16 (citing Ex. 2037, 37:17–43:17 (Dr. Cooperstock "could not explain how the speaker elements disclosed in Rosener operate or even how they compare to one another.")).

Patent Owner argues a person of ordinary skill in the art "would not necessarily have any skills or knowledge specific to designing the acoustic transducer for a wireless earphone, fitting all of the components into a small form factor earphone, or suitably powering a wireless earphone given the safety and size constraints." PO Resp. 6–7 (citing Ex. 2038 ¶ 20); *see also id*. at 16 (alleging Dr. Cooperstock, has skills superior to a person of ordinary skill in the art, "could not explain how the speaker elements disclosed in Rosener operate" (citing Ex. 2037, 37:17–43:17)). Patent Owner argues a person of ordinary skill would need to overcome problems relating to the design and construction of "operative wireless earphones," including sound quality and "form factor[12]" considerations. *Id*. at 16 (citing Ex. 2038 ¶ 50).

Because of these alleged complexities as compared to the relatively low level of skill applicable here, Patent Owner argues generally that "it would not have been obvious to a [person of ordinary skill in the art] . . . to make the combinations proposed by Petitioner for claim 1." PO Resp. 18 (citing Ex. 2038 ¶ 56). Patent Owner contends specifically that Dr.

[12] We find "form factor" refers to the physical design of the "earphone." *See*, *e.g.*, Ex. 1003 ¶ 45; Ex. 2038 ¶ 20.

Cooperstock could not discern a difference between separately numbered "DATA SOURCE" 618 in Figure 6 and "DATA SOURCE" 922 in Figure 9 of Rosener. *Id*. at 19 (citing Ex. 2037, 102:21–103, 12 ("they're referring to the same data source")). Patent Owner argues the described "DATA SOURCE[S]" 618 and 922 are different. *Id*. (citing Ex. 2037, 102:10–18 (DATA SOURCE 922 could be a "sensor or a microphone.")). According to Patent Owner the "DATA SOURCE 618," which Rosener explains "may be provided from a digital audio data output of an MP3 player, CD player, PC, PDA, mobile telephone, game console, component of an entertainment system, etc." *Id*. at 19–20 (citing Ex. 2038 ¶ 68 (quoting Ex. 1004 ¶ 33)).

Patent Owner argues that Dr. Cooperstock has a skill level beyond that of the person of ordinary skill and cannot "ascertain whether data source 922 is a sensor/microphone incorporated into a wireless earphone or is a digital or audio data source like an MP3 player that is external to the wireless earphone." PO Resp. 19. As a result of this complexity, as evidenced by Dr. Cooperstock's alleged lack of understanding, Patent Owner alleges the person of ordinary skill "would not have a reasonable expectation of success implementing Rosener's headset within the compact form factor of Hankey." *Id*. at 19–20 (citing Ex. 2038 ¶ 68). Patent Owner also cites Dr. Cooperstock's inability to identify a "suitable material for the flexible electrical connector" as disclosed in Hankey. PO Resp. 20 (citing Ex. 2037, 67:1–68:4).

We agree with Petitioner and find that Rosener's Figure 5 expressly discloses "each of earphones 502, 504 ***is inserted into an ear of the user when worn by the user***. Since '[e]ach of the first and second earphones 502, 504 may be . . . a canalphone, which can be fitted within the ***ear canal***

of the user's ear,' each of the earphones has ***an ear canal portion***." Pet. 44 (citing Ex. 1003 ¶¶ 34, 109; Ex. 1004 ¶ 30) (alteration in original). Patent Owner's complexity arguments are predicated on bodily incorporation. That is not the test for obviousness. As noted below, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *In re Keller*, 642 F.2d 413, 425 (C.C.P.A. 1981).

We agree with Petitioner and find that design and implementation details of the headphones would have been well-known, i.e., "suggested to those of ordinary skill in the art." Reply 9. As Petitioner argues specifically, a person of ordinary skill in the art would have understood how to make the claimed headphones. *Id*. (citing Ex. 1024 ¶ 13); *see also* Ex. 2037, 39:11–17 (Dr. Cooperstock Deposition testimony regarding availability of "many references" to an engineer regarding speaker technology).

We also agree with Petitioner and find that "the properties, characteristics, and use of audio transducers (the transducer types disclosed in Rosener) were all well-known by the Critical Date." Reply 10 (citing Ex. 2037, 39:6–17, 38:3–9; Ex. 1025, 182:13–194:4 (Mr. McAlexander deposition testimony that different speakers have different transducers and different applications)). We find that materials for flexible electrical connectors were also well-known by the Critical Date. *See* Reply 12 (citing Ex. 1025, 199:15–201:4 (the '982 patent disclosure "is sufficient to enable a person of ordinary skill in the art to make a set of headphones as claimed in the patent")). Dr. Cooperstock cites to prior art on flexible wiring circuit

boards. Ex. 1024 ¶ 22 (identifying Exs. 1027[13], 1028[14], and 1029[15] as prior art references disclosing exemplary materials). For example, Exhibit 1027 discloses "[a] flexible wiring board." Ex. 1027, Abs. We find that if a person of ordinary skill in the art could make the invention described and claimed in the '982 patent, the combination would likewise be made based on the same level of disclosure in Rosener. *In re Epstein*, 32 F.3d 1559, 1568 (Fed. Cir. 1994).

In sum, Patent Owner's argument is that if the expert cannot succeed in making the combination then neither can the person of ordinary skill in the art.

> The test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary reference; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art.

In re Keller, 642 F.2d at 425.

The claims do not include limitations regarding design and operability. Our inquiry is what the combined teachings of the references would have suggested to those of ordinary skill in the art who

> would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks.

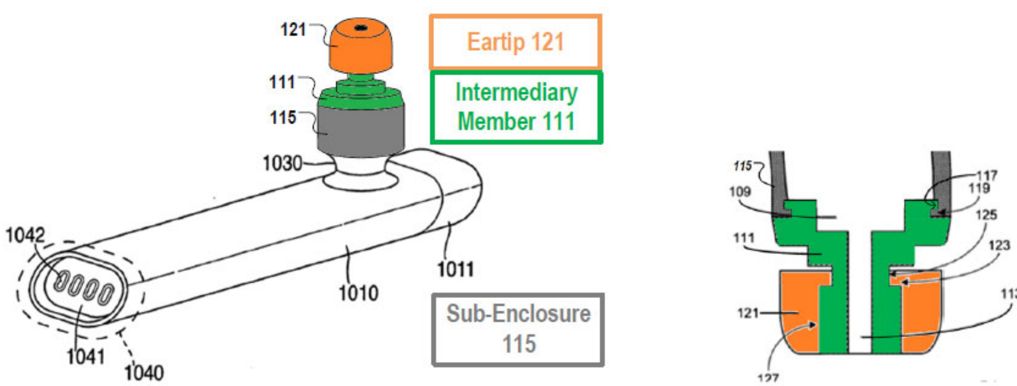
[13] Sera, US Patent No. 5,733,598, issued Mar. 31, 1998 (Ex. 1027).
[14] Lee, US Patent No. 7,281,328 B2, issued Oct. 16, 2007 (Ex. 1028).
[15] Myoung, US Patent No. 7,453,045 B2, issued Nov. 18, 2008 (Ex. 1029).

Section III.A above. We are not persuaded that the design and operational issues raised by Patent Owner would have precluded a person of ordinary skill in the art from understanding the references and any differences between the references and claim 1. Patent Owner does not allege the references teach away from the combination.

Based on the preceding findings, including Petitioner's argument and evidence summarized above, which we adopt, we determine that a person of ordinary skill in the art would have had a reasonable expectation of success in making the asserted combination of Rosener and Hankey.

b. Rosener, Hankey, and Dyer Reasons for Combination

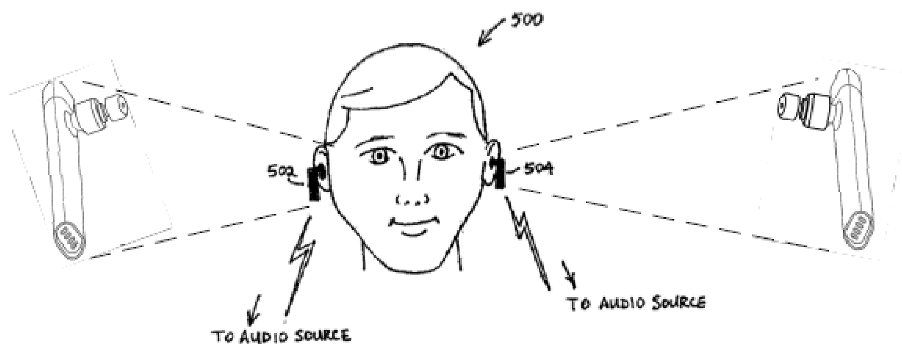
To the extent any structure is argued as necessary by Patent Owner, Petitioner cites to Dyer.[16] Pet. 29 (citing Ex. 1003 ¶ 54). Petitioner alleges motivation to add Dyer based on Dyer and Rosener both describing a "'canal phone' with an element that extends into the user's ear canal." *Id.* at 30 (citing Ex. 1003 ¶ 54). This combination is illustrated by an annotation showing the Rosener, Hankey, and Dyer canalphone compared to Dyer's canalphone, which is reproduced below.



[16] Petitioner adds Dyer as an alternative to the combination of Rosener and Hankey contending "Rosener alone sufficiently shows . . . insertion of a canalphone into a user's ear." Reply 14–15.

Comparison on the left of the canalphone combining Rosener, Hankey, and Dyer and on the right part of Dyer's canalphone.

Pet. 31. Referring to the above annotation, Petitioner explains that a person of ordinary skill in the art "would employ Hankey's techniques of arranging circuitry within small housings to configure the supporting circuitry within sub-enclosure 115 of the Rosener-Hankey-Dyer canalphone." *Id*. (citing Ex. 1005 ¶¶ 202–204, Figs. 20A–C). Petitioner further explains "Dyer's acoustic elements, including its sound delivery tube 113 in intermediary member 111, would deliver sound from the circuitries in sub-enclosure 115 to eartip 121." *Id.* (citing Ex. 1005 ¶¶ 202–204, Figs. 20A–C; Ex. 1003 ¶ 57). An illustration from page 32 of the Petition is reproduced below.



Rosener-Hankey-Dyer system.

Combination of Rosener Figure 5 and annotation of Rosener, Hankey and Dyer (reproduced immediately above).

The illustration above shows a one for one substitution of the Rosener, Hankey, and Dyer canalphone for the earpieces of the Rosener, showing the "Rosener-Hankey-Dyer system." *Id*. at 32.

Patent Owner argues the addition of Dyer's canalphone to the Rosener and Hankey combination "would not stay in a user's ear" and would cause discomfort "because the 'canalphone does not include an adequate securing mechanism, and the 'body portion' thereof forms an extended cantilevered arm between the in-ear portion of the canalphone and the primary housing 1010, which would generate a significant torque at the in-ear portion from the offset weight of the primary housing." PO Resp. 35 (citing Ex. 2039 (Blair Declaration) ¶ 20). Mr. Blair testifies to significant experience designing earphones and headphones. Ex. 2039 ¶ 4.

Relying on the Blair Declaration, Patent Owner argues how each of Rosener, Hankey and Dyer are supported in the ear. PO Resp. 37 (citing Ex. 2039 ¶¶ 10, 12–13). Patent Owner argues Rosener and Hankey are kept in place by the weight of the earbud hanging in the "intratragal notch" of the ear. *Id*. at 36–37 (citing Ex. 2039 ¶¶ 10, 12). Patent Owner argues

Dyer relies on a different method of support where the "earphone 100 is secured within a user's ear by 'a seal between the eartip 121 and the user's ear canal.'" *Id*. at 37 (citing Ex. 2039 ¶ 13). Patent Owner alleges the failure to stay in the user's ear argument would worsen the performance of the earbud and motivation to make the combination would be absent. *Id*. at 39 (citing Ex. 2038 ¶ 62).

Patent Owner criticizes Dr. Cooperstock's testimony, arguing the "entire 'body portion' in Cooperstock's Rosener-Hankey-Dyer canalphone would ***not*** fit in a user's ear because the 'body portion' defines a straight structure that 'does not account for the ear canal's geometry' and 'does not complement the shape of the user's ear canal.'" PO Resp. 37–38 (citing Ex. 1003 ¶ 98 (the body portion of Rosener's earphones "is inserted into an ear of user"); Ex. 2039 ¶ 16 ("Cooperstock's 'body portion' does not account for the ear canal's geometry.")). Patent Owner also asserts that the securing method where the "body portion" of Rosener is inserted into the ear would not be secure. *Id*. at 39 (citing Ex. 2039 ¶ 18). Patent Owner concludes that "performance of the earbud" is worse in the Rosener, Hankey, and Dyer combination and a person of ordinary skill in the art would not be motivated to make such a modification. *Id*. (citing Ex. 2038 ¶¶ 57–62).

Hankey discloses small earpieces capable of communicating with external audio devices wirelessly. Ex. 1005 ¶¶ 93, 103 ("wireless connection"). We find Hankey's small form factor wirelessly connected earpieces resolve the problems identified by Rosener, i.e., "single earpiece monaural devices" or "bulky . . . wired connections" between earpieces, and is a reason to combine the two references. *See* Pet. 24–25 (citing Ex. 1004 ¶¶ 3–10, Figs. 1–4).

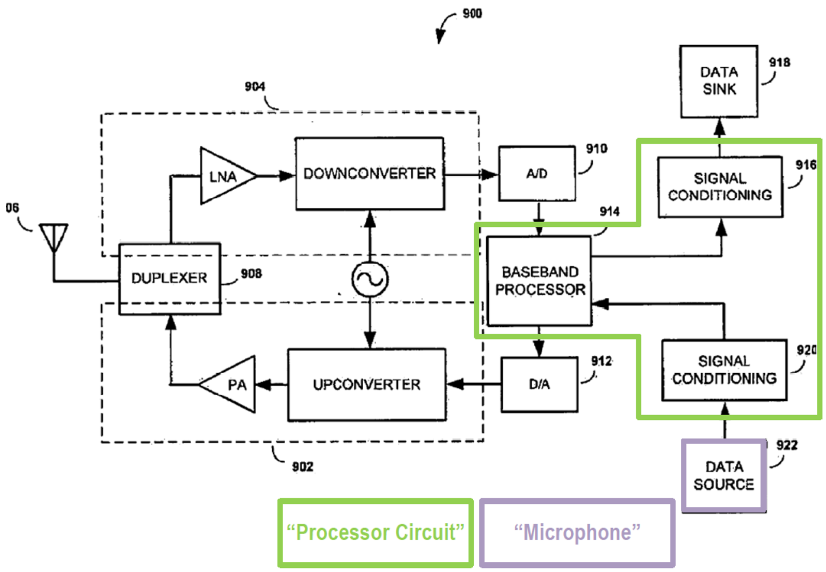
We are not persuaded we should discount the Blair Declaration because he is an employee of Patent Owner and thus is the "testimony of an interested Declarant." *See* Reply 15. Petitioner further argues that Mr. Blair's testimony is conclusory and uncorroborated. *Id*. In support, Petitioner offers testimony from Dr. Cooperstock, although that testimony is also conclusory and does not identify the basis for the testimony. *Id*. at 16 (citing Ex. 1024 ¶¶ 29–31). We give neither expert conclusive weight on the design issues presented.

We are not persuaded by Patent Owner's argument that the Rosener, Hankey, and Dyer combination would not stay in the ear of a user. We find a person of ordinary skill in the art "would have recognized that Rosener's disclosure of a canalphone could be implemented in the Rosener-Hankey combination as advanced in the Petition to provide a superior securing mechanism than an earphone configuration, like that disclosed in Hankey." Reply 18. Patent Owner's response is based on the Blair Declaration, which we determined above is not conclusive on this point. *See* Sur-Reply 13–14. We adopt as our findings Petitioner's argument and evidence summarized above in the Petition and Reply. Pet. 48–49; Reply 11–12. As We find the Rosener, Hankey, and Dyer obviousness claim to be supported by rational underpinnings.

c. Limitation 1.c.iii

Limitation 1.c.iii recites "a microphone connected to the processor circuit and for picking up utterances of a user of the headphones." Petitioner's evidence includes Rosener's teaching that earphones 502 and 504 may include a microphone connected to a processor. Pet. 48 (citing Ex. 1004 ¶ 56; Ex. 1003 ¶¶ 119–120). Petitioner's Annotated Figure 9 is

reproduced below.



Rosener Annotated Figure 9 showing a diagram of an RF transceiver.

Pet. 49. As shown in Annotated Figure 9, Rosener discloses a data source 922 which "provides an input to signal conditioning circuit 920 and baseband processor 914 ("***connected to the processor circuit***"), which process the inputted data prior to providing it to RF transmitter portion 902 for transmission via antenna 906. *Id.* at 48–49 (citing Ex. 1004 ¶ 50). Petitioner contends Rosener's data source 922 is "***a microphone for picking up utterances of a user of the headphones***." *Id.* at 48 (citing Ex. 1003 ¶ 120; Ex. 1004 ¶ 56). The connection between the microphone and processor is illustrated by Petitioner's annotation of Rosener's Figure 9 showing the "Processor Circuit" and "Microphone." *Id.* at 49 (citing Ex. 1004 ¶ 50).

Patent Owner disputes limitation 1.c.iii has been shown. *See* PO Resp. 21–31. Patent Owner argues Rosener does not teach that "both earphones include its own microphone." *Id.* at 21.

Paragraph 56 of Rosener is set forth below.

> According to an embodiment of the invention, either or both the first and second data sinks of the various embodiments may ***include (or be coupled to) a data source*** such as, for example, ***a sensor or a microphone*** to allow a data to be sent back to an external electronic device.

Ex. 1004 ¶ 56 (emphasis added). Patent Owner contends the above quotation from Rosener, upon which Petitioner relies for the limitation, simply provides "examples of generic data sources for the data sinks." PO Resp. 22 (citing Pet. 48 (quoting Ex. 1004 ¶ 56). Patent Owner argues that none of those arrangements conclusively includes a microphone in each earphone. *Id*. Patent Owner further argues paragraph 56 means "in one embodiment, one of the data sinks includes the data source and, in another embodiment, both data sinks are coupled to the data source." *Id*. (citing Ex. 2038 ¶ 64).

For example, one arrangement Patent Owner identifies is "[b]oth earphones being coupled to a data source, which can be the same data source or different data sources." PO Resp. 23. Another arrangement Patent Owner identifies is "[o]ne earphone including a data source, and the other earphone being coupled to a data source." *Id*. Patent Owner disputes that a person of ordinary skill in the art would find it obvious to include a microphone in each of Rosener's earphones. Resp. 32–34. Patent Owner alleges that "[w]ithout the benefit of the '982 Patent's disclosure, a [person of ordinary skill in the art] would not have modified the Rosener-Hankey combination (or the Rosener-Hankey-Dyer combination) to include a microphone in each wireless earphone." *Id*. at 32 (citing Ex. 2038 ¶ 70).

For reasons discussed below, we find both of Patent Owner's examples teach that the "data source" is a microphone, one for each earphone.

We are not persuaded that separate embodiments where Rosener has a single microphone limit its disclosure to a single microphone. Patent Owner relies on Figure 13 as such an instance. PO Resp. 23–25. Patent Owner acknowledges Rosener's paragraph 56 describes "the *particular embodiment* shown in Figure 13, which includes a single microphone and two data sinks." *Id*. at 23–24 (reproducing Figure 13) (emphasis added). Patent Owner makes a similar argument for Figures 6 and 9 of Rosener, contending a microphone is never mentioned in the description of either. *Id*. at 26. We find paragraph 56 broadly discloses the data source may be a microphone in teaching that "either or both the first and second data sinks of the various embodiments may include (or be coupled to) a data source." Ex. 1004 ¶ 56. The first and second data sinks are disclosed as "speakers." *Id*. ¶ 38. As a result, two data sinks may include or be coupled to two speakers. *See* Ex. 1004 ¶ 56 ("either or both . . . data sinks").

Paragraph 56 applies to "various embodiments," which we find includes the separate embodiments shown in Figures 6 and 9. *See* Reply 11 (citing Ex. 1024 ¶¶ 18–19); *see also* Ex. 1003 ¶ 120[17] (citing Ex. 1004 ¶ 56). Beyond asserting the disclosed "data source" is not a microphone in the earphone, Patent Owner does not respond to the separate embodiment issue. Sur-Reply 12 (citing Ex. 1004 ¶¶ 33–34). Paragraphs 33 and 34 of

[17] The relevant Cooperstock Declaration testimony is "[i]n the earphone of FIG. 9, data source 922 can be a microphone (***a microphone for picking up utterances of a user of the headphones***) 'to allow a data to be sent back to an external electronic device.'"

Rosener are not relevant in that they only describe the data source of Figure 6. See Section III.D.4.a above.

Patent Owner cites alleged inconsistencies in Dr. Cooperstock's testimony regarding the "data sources" shown in Rosener's Figures 6 and 9. Sur-Reply 12 (citing Ex. 1003 ¶ 120; Ex. 2038 ¶¶ 65–66; Ex. 1024 ¶ 18). Dr. Cooperstock's original declaration stated that Rosener's "data source" is "a sensor/microphone incorporated within an earphone" and any inconsistency testified to at his deposition "slipped his eyes." Ex. 1024 ¶ 18 (citing Ex. 1003 ¶ 120). A mistake was made and clarified. We do not find the mistake diminishes the Cooperstock Declaration, which is based on the compelling evidence of Rosener's paragraph 56. Ex. 1003 ¶¶ 119–120. We discussed the Cooperstock testimony above in Section III.D.4.a. We find the arguments based on a mistake in the Cooperstock Deposition unpersuasive. *See* Ex. 1024 ¶ 28 (Dr. Cooperstock's testimony explaining his mistake).

Based on the preceding findings, including Petitioner's argument and evidence summarized above, which we adopt, we determine that a person of ordinary skill in the art would have found Rosener and Hankey or Rosener, Hankey, and Dyer teach Limitation 1.c.iii.

d. Claim 1 Remaining Undisputed Limitations

We summarize Petitioner's argument and evidence on the remaining limitations of claim 1 below. Patent Owner does not dispute the remaining limitations. *See* PO Resp. 12–40.

Recitation 1.P, the preamble of claim 1, recites "a system comprising." Although we do not find the preamble to be limiting, Petitioner cites to Rosener as disclosing "a wireless system." Pet. 32 (citing

Ex. 1004 ¶¶ 30, 56; Ex. 1003 ¶ 89. Even if the preamble was limiting, we find that Rosener teaches the recited system.

Limitation 1.a recites "headphones comprising a pair of first and second wireless earphones to be worn simultaneously by a user." Rosener teaches "a wireless headset comprising first and second wireless earphones." Ex. 1004 ¶ 30. The '982 patent states earphones may be "in-ear type headphones," such as disclosed by Rosener. Ex. 1001, 1:50–2:3. Petitioner relies on the preceding as teaching limitation 1.a. Pet. 32–33 (citing Ex. 1004 ¶ 30; Ex. 1003 ¶ 91).

Limitation 1.b recites "wherein the first and second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected." Petitioner cites to Rosener's earphones 502 and 504 in Figure 5 as "physically and electrically" separated when worn. Pet. 33 (quoting Ex. 1004 ¶ 11; Ex. 1003 ¶ 92).

Limitation 1.c recites "wherein each of the first and second earphones comprises." Petitioner points to the fact that a person of ordinary skill would have understood Rosener's earphones each have identical components. Pet. 33–34 (citing Ex. 1004 ¶¶ 30, 46, 49, Figs. 6, 8A–B; Ex. 1003 ¶ 93).

Limitation 1.c.i recites "a body portion that comprises." Petitioner argues Rosener teaches "[e]ach of the first and second wireless earphones 502, 504 comprises a housing containing a speaker, an RF receiver or transceiver and a battery." Pet. 34 (quoting Ex. 1004 ¶ 30). Petitioner contends that Hankey adds teachings regarding the arrangement of electronic components, i.e., "a top portion (***body portion***) of the earpiece,

and a longitudinal member (***elongated portion***) extending away from the top portion." *Id.* (citing Ex. 1005 ¶¶ 94–98, 107–115, 143–144; Ex. 1008,[18] Figs. 1A–B, 20A–C, ¶¶ 89–91; Ex. 1003 ¶ 95).

Limitation 1.c.i.A recites "a wireless communication circuit for receiving and transmitting wireless signals." Petitioner alleges "Rosener discloses that each of earphones 502, 504 includes an RF transceiver circuit (***wireless communication circuit***)." Pet. 36 (citing Ex. 1004 ¶¶ 11, 30). Relying on the Cooperstock Declaration and Figure 9 of Rosener, Petitioner further alleges "[t]he transceiver 900 includes RF transmitter portion 902, RF receiver portion 904, duplexer 908, analog-to-digital (A/D) converter 910, and digital-to-analog converter (D/A) (collectively '***a wireless communication circuit***')." *Id.* at 37 (citing Ex. 1004 ¶¶ 30–36, 49, Fig. 9 (annotated at Pet. 37 to show "Wireless Communication Circuit"); Ex. 1003 ¶¶ 99–100). Petitioner also cites to Hankey as teaching "RF circuitry 1520 is part of a processor 20, which is located inside the earpiece's body portion, a [person of ordinary skill] would have been led to similarly position Rosener's transceiver circuitry (***wireless communication circuit***) in the ***body portion*** of the earphone." *Id.* at 38 (citing Pet. 39, annotated Figs. 1, 15 (Figures 1 and 15 annotated to show "Body portion," "Hankey's Processor 20," "Wireless Communication Circuit," and "Hankey's Processor 20"); Ex. 1008, Fig. 5; Ex. 1003 ¶¶ 92–93, 122).

Limitation 1.c.i.B recites "a processor circuit in communication with the wireless communication circuit." Petitioner relies Rosener's Figure 9 to show this limitation. Pet. 40. Specifically, Petitioner alleges Figure 9

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[18] As noted above, the Hankey Provisional cite is for purposes of establishing entitlement to its earlier priority date. See Section II.E above.

includes "components that perform signal processing functions, such as a baseband processor 914 and signal conditioning circuits 916 and 920, and 'additional circuitry and processing capabilities' that 'operate in accordance with different wireless technologies,'" which is a "processor circuit." Pet. 40 (quoting Ex. 1004 ¶¶ 49–51, Fig. 9 (annotated at Pet. 41 to show "Wireless Communication Circuit" and "Processor Circuit"); Ex. 1003 ¶ 104). Petitioner also cites to Hankey's teaching of a processing circuitry located in the body portion of Hankey's earpiece. *Id.* at 41–42 (citing Ex. 1005 ¶¶ 176, 178, Fig. 15; Ex. 1008 ¶¶ 122, 124, Fig. 5; Ex. 1003 ¶ 106–107).

Limitation 1.c.i.C recites "an ear canal portion that is inserted into an ear of the user when worn by the user." As discussed above (Section IV.E), we find this limitation is taught by Rosener. *See* Pet. 44 (citing Ex. 1004 ¶ 30 (earphones may be an earbud "designed to fit into the concha of the pinna of the user's ear; a canalphone, which can be fitted within the ear canal of the user's ear"); Ex. 1003 ¶¶ 34, 109).

Limitation 1.c.i.D recites "at least one acoustic transducer connected to the processor circuit." Petitioner cites Rosener's teaching that each earphone has a speaker in the form of an "acoustic transducer" electrically connected to receivers or transceivers. Pet. 45 (citing Ex. 1004 ¶¶ 2, 30–31, 38, 49 (transceiver connect to other components of the earphone), Fig. 6). Relying on the Cooperstock Declaration, Petitioner alleges that the data sink 918 shown in Figure 9 of Rosener is a speaker, i.e., the claimed acoustic transducer, connected to a processor circuit. *Id.* at 45 (citing Ex. 1004, Fig. 9 (annotated at Pet. 45 showing "Acoustic transducer," "data sink," and "Processor Circuit")).

Petitioner also cites to Hankey as teaching this limitation. Pet. 45–46. Petitioner argues Hankey teaches speakers in the earbud which would have suggest to a person of ordinary skill in the art to "position[ed] Rosener's acoustic transducer in the earphone's body portion as well." *Id.* at 46 (citing Ex. 1005, Fig. 1 (annotated at Pet. 46 showing "Body portion" and "Acoustic transducer"); Ex. 1008 ¶¶ 2, 89; Ex. 1003 ¶ 113).

Limitation 1.c.ii recites "an elongated portion that extends away from the body portion such that the elongated portion extends downwardly when the ear canal portion is inserted in the ear of the user." Petitioner relies largely on Rosener's Figure 5 showing both an "elongated portion" and an "ear canal portion" to teach the limitation. Pet. 47 (citing Ex. 1004, Fig. 5 (annotated at Pet. 47 showing "Elongated portion" and "Body portion"); Ex. 1003 ¶ 115). Hankey is also cited for its teaching of "a ***body portion*** that includes earbud 12, and a longitudinal member ('***an elongated portion'***) ***that extends away from the body portion***." *Id.* (citing Ex. 1003 ¶¶ 116–117).

Limitation 1.c.iv recites "an antenna connected to the wireless communication circuit." Petitioner relies on each of Rosener's earphones including "an ***antenna*** 906 ***connected to the wireless communication circuit*** (i.e., transmitter portion 902, receiver portion 904, duplexer 908, A/D 910, D/A 912)." Pet. 49 (citing Ex. 1004 ¶ 50, Fig. 9 (annotated at Pet. 50 showing "Antenna" and "Wireless communication circuit"); Ex. 1003 ¶ 121).

Limitation 1.c.v recites "a rechargeable power source." Rosener is cited for its disclosure that "each of the earphones includes a battery (***power source***)." Pet. 50 (citing Ex. 1004 ¶ 30). According to Petitioner a

rechargeable battery would have been obvious to a person of ordinary skill because it would "extend the use of the battery and reduce or remove the hassle and cost of periodically replacing non-rechargeable empty batteries." *Id.* (quoting Ex. 1003 ¶ 122). Petitioner also relies on Hankey's teaching "that using rechargeable batteries in headsets was 'traditional[].'" *Id.* (citing Ex. 1005 ¶ 190; Ex. 1008 ¶ 136; Ex. 1003 ¶123).

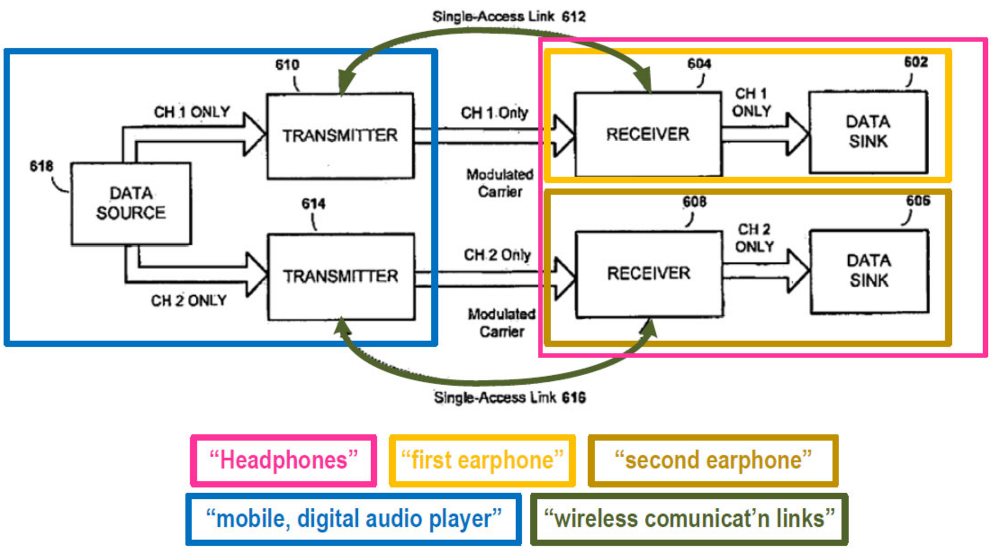
Limitation 1.d recites

> a mobile, digital audio player that stores digital audio content and that comprises a wireless transceiver for transmitting digital audio content to the headphones via Bluetooth wireless communication links, such that each earphone receives and plays audio content received wirelessly via the Bluetooth wireless communication links from the mobile, digital audio player.

Petitioner argues Rosener discloses the claimed "mobile, digital audio player" in describing that the earphones communicate with "exemplary external audio devices, including audio players (e.g., MP3 player) that are both digital and mobile." Pet. 51 (citing Ex. 1004 ¶ 2; Ex. 1003 ¶ 124). Petitioner argues a person of ordinary skill in the art "would have understood that a typical MP3 player is mobile and stores digital audio content in the form of, for example, MP3 files and transmits such content to the earphones to be played." *Id.* (citing Ex. 1001, 4:39–43 ("providing MP3 player as an example data source for wirelessly sending and receiving digital audio to and from earphone 10"); Ex. 1003 ¶ 125; *see also* Ex. 1004 ¶ 2 (disclosing mobile, digital audio player to store audio content)).

Petitioner relies on Rosener's teaching that the "wireless communication links can be in the form of Bluetooth communication links." Pet. 52 (citing Ex. 1004 ¶ 35). Petitioner also cites the RF

transmitter and RF receivers used in Rosener's earphones as well as bidirectional transmission over wireless communication links as illustrated in Petitioner's annotation of Rosener's Figure 6 reproduced below.



APPLE-1004, FIG. 6 (annotated).

Rosener's Annotated Figure 6 showing a wireless system.

Pet. 52. As shown in Annotated Figure 6, Petitioner alleges "Rosener also discloses that an external device sends audio content to the earphones through multiple ***wireless communication links*** 612 and 616." Pet. 51–52 (citing Ex. 1004 ¶ 32). Petitioner also asserts the "wireless communication links can be in the form of ***Bluetooth*** communication links." Id. at 52 (citing Ex. 1004 ¶ 35). Petitioner relies on the Cooperstock Declaration for the assertion that a person of ordinary skill would have been motivated to use transmitters/transceivers to "improve processing and communication speed, and to reduce noise." *Id.* at 53 (citing Ex. 1003 ¶ 127). Additional reasons for including a wireless transceiver are also provided by the Cooperstock Declaration and further include that the external devices

disclosed in Rosener "were known to include both wireless transceivers and data storage." *Id*. (citing Ex. 1003 ¶ 127; Ex. 1004 ¶ 30).

If Dyer is necessary for Petitioner to make its showing, which we do not find necessary as summarized above, Petitioner has sufficiently shown a person of ordinary skill would have been motivated to combine Dyer and Rosener because both teach "the same type of earphone – a 'canal phone' with an element that extends into the user's ear canal." Pet. 29–30 (citing Ex. 1003 ¶ 54). This proposed combination of "the Rosener-Hankey canalphone is implemented using Dyer's canalphone elements, including a portion of Dyer's enclosure 115 (which is referred to as the 'sub-enclosure 115' herein) that supports intermediary member 111, along with intermediary member 111 and eartip 121." *Id.* at 30 (citing Ex. 1003 ¶¶ 55–56; Ex. 1006, 2:21–24); *see also* Pet. 31 (annotation at Pet. 31 showing "Eartip 121," "Intermediary Member 111," and "Sub-Enclosure 115"); see also annotation in Section III.D.4.b above (depicting elements 111, 115 and 121).

As summarized above, we adopt Petitioner's argument and evidence regarding claim 1 as our own findings. Petitioner has sufficiently shown recitation 1.P and limitations 1.a, 1.b, 1.c, 1.c.i, 1.c.i.A, 1.c.i.B, 1.c.i.C, 1.c.i.D, 1.c.ii, i.c.iv, 1.c.v and 1.c. are taught by the combination of Rosener and Hankey or Rosener, Hankey, and Dyer.

5. Claims 2 and 18

Claims 2 and 18 depend from claim 1. We have reviewed Petitioner's showing with respect to claims 2 and 18. Pet. 53–55. Patent Owner does not dispute Petitioner's showing with respect to claims 2 and 18. We summarize our findings below.

Claim 2 depends from claim 1. Petitioner shows that the "docking station" recited in limitation 2.a is taught by Hankey's charging device 6600. Pet. 53–54 (citing Ex. 1005 ¶¶ 315–320). Limitation 2.b's recited "power cable for connecting to an external device for charging the at least the first wireless earphone" is sufficiently shown by Hankey's charging device. *Id.* at 54–55 (citing Ex. 1005 ¶ 320; Ex. 1003 ¶¶ 128–130).

Claim 18 depends from claim 1 and recites, in pertinent part, "a buffer for caching the audio content received by the earphone prior to being played by the at least one acoustic transducer of the earphone." Petitioner cites Rosener's teaching that "'the first and second data streams' [are] sent to the first and second earphones 502, 504 by using the data buffer ('***buffer***') included in each of the earphones." Pet. 55 (citing Ex. 1004 ¶ 39–42).

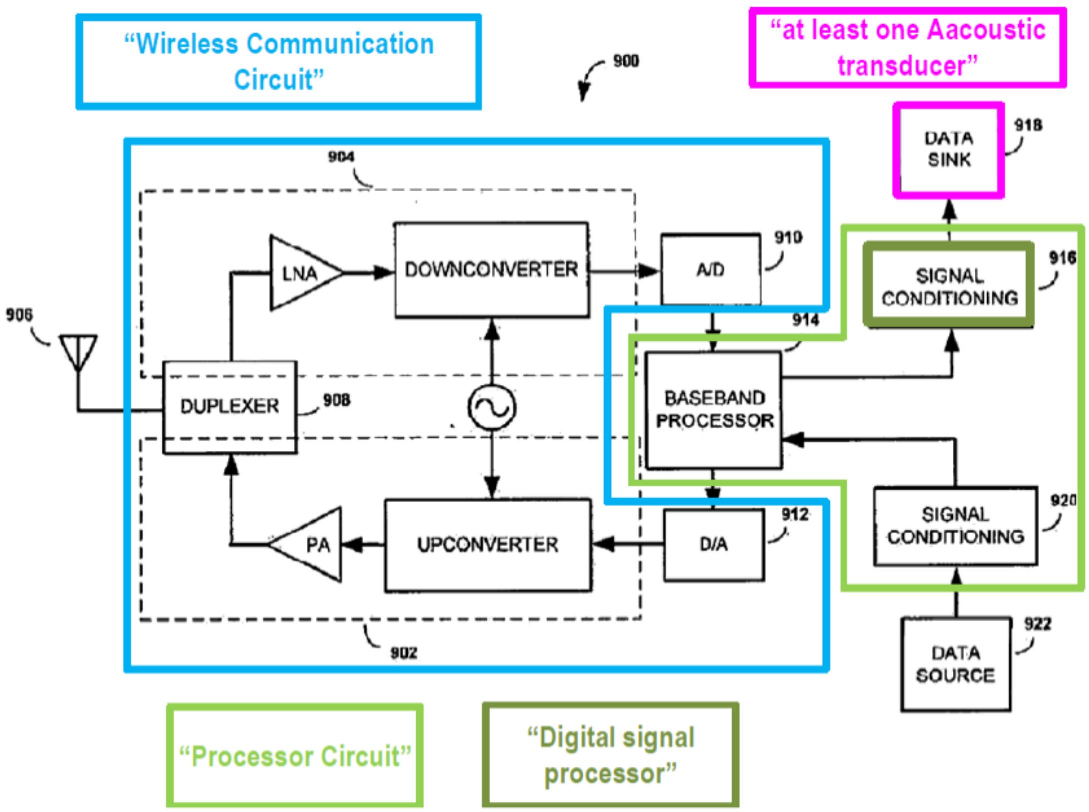
As summarized above, we adopt Petitioner's argument and evidence regarding claims 2 and 18 as our own findings. Pet. 53–55. Petitioner has sufficiently shown that the combination of Rosener and Hankey or Rosener, Hankey, and Dyer teaches claims 2 and 18.

6. Claims 19 and 20

Claim 19 depends from claim 1 and claim 20 depends from claim 19. We have reviewed Petitioner's showing with respect to claims 19 and 20. Pet. 55–58. Claim 19 recites, in pertinent part, that each of the claimed headphones have a "processor circuit" where "the first and second earphones comprises a digital signal processor" for "sound quality enhancement." Rosener is relied on by Petitioner, as it was for limitation 1.c.i.B, for, among other things, its teaching of "signal conditioning circuitry 916 [that] filters and amplifies the audio content to enhance the

sound quality to be played by data sink 918." Pet. 56 (citing Ex. 1004 ¶ 49, *see also* Ex. 1004 ¶¶ 10–11 ("indicating that Rosener's earphones provide 'high-quality stereo sound'")).

Petitioner provides an annotation of Rosener's Figure 9 in support of its arguments. Annotated Figure 9 is reproduced below.



APPLE-1004, FIG. 9 (annotated).

Annotated Figure 9 of Rosener showing an RF transceiver that may be used in place of one or more of the RF transmitters and receivers.

Pet. 57; Ex. 1004 ¶ 24. Specifically, Annotated Figure 9 shows a "digital signal processor," as per claim 19. Ex. 1003 ¶ 132 ("The signal conditioning circuitry ***provides a sound quality enhancement of the audio content*** to be played by data sink 918 (***at least one acoustic transducer of the earphone***).").

Claim 20 depends from claim 19 and recites, in pertinent part, "a baseband processor circuit that is in communication with the wireless communication circuit of the earphone." Petitioner cites to Rosener's teaching "that A/D converter 910 (a component of '***wireless communication circuit***') 'digitizes the signals, and sends the digitized baseband signals to a baseband processor 914.'" Pet. 57 (quoting Ex. 1004 ¶ 49; *see also* Ex. 1003 ¶¶ 133–134).

With reference to Annotated Figure 9, Patent Owner argues "Rosener's signal conditioning circuit converts the digital signal from the baseband processor 914 to an analog signal because the data sink/speaker 918 is driven by an analog signal." PO Resp. 62 (citing Ex. 2039 ¶ 90). Patent Owner argues that the signal conditioning circuit describes a digital-to-analog converter (DAC) and not a digital signal processor. *Id.* at 62–63 (citing Ex. 2039 ¶¶ 35, 91; Ex. 1004 ¶ 49). Patent Owner contends "[t]he 'P' in DSP stands for processor." *Id.* at 63 (citing Ex. 2038 ¶ 93). According to Patent Owner, the difference is important because neither "Rosener's baseband processor nor signal conditioning circuit . . . is a processor that performs signal processing operations, including providing a noise quality enhancement." *Id.* (citing Ex. 2038 ¶93). Patent Owner then asserts that:

> claim 19 recites that the DSP "provides a sound quality enhancement . . . ." [Ex. 1001, 20:29–30]. The '982 Patent lists several sound quality enhancements that could be performed by the DSP, such as "noise cancellation and sound equalization." APPLE-1001, 7:41. A person of ordinary skill in the art would understand that these are sound quality enhancements performed by a DSP, because that is what DSPs do in speakers – improve audio signal prior to delivery to a speaker. [citing Ex. 2038 ¶ 96]. A [person of ordinary skill in the art] would also understand that

> the DSP does not "drive" the speaker because it does not control the voltage and current of the drive signal; i.e., a DSP circuit that improves the signal quality does not convert that digital signal to analog, like a DAC, in order to drive a speaker element. *Id.*

Id. at 64.

Petitioner responds that although Rosener's signal conditioning circuit 916 is a digital-to-analog converter it also performs "signal processing functions." Reply 26 (citing PO Resp., 61–62 (agreeing that signal processing functions occur)); *see also id*. at 29–30 (similarly arguing the signal condition circuit performs the functions alleged to be performed by the DSP). According to Petitioner, this argument is supported by Rosener's disclosure of "signal processing functions." *Id*. (citing Ex. 1004 ¶¶44, 47, 50). Petitioner also argues a person of ordinary skill in the art "would have understood that signal conditioning circuit 916 includes a DSP that processes the digital signal before converting the signal to analog." *Id*. (citing Ex. 1025, 160:2–161:4 (Mr. McAlexander testifying filtering of a signal occurs before and after digital-to-analog conversion); Ex. 1004 ¶ 61).

Petitioner also argues Patent Owner construes digital signal processor to distinguish it from a digital-to-analog converter. Reply 28–29. In sum, Petitioner argues the DSP should be interpreted on its plain meaning. *Id*. at 28. Patent Owner does not propose a construction beyond arguing that a digital-to-analog converter is not a digital signal processor and a person of ordinary skill in the art "would not understand that Rosener's signal conditioning circuit 916 is a digital signal processor as recited in claim 19." *See*, *e.g*., PO Resp. 61 (citing Ex. 2038 ¶ 90). Petitioner argues that Patent Owner's contention that a DSP is "embodied as a single chip (i.e., integrated circuit)" is also improperly narrow. Reply 29 (citing PO Resp.

64). Patent Owner responds that "amplifiers and filters can be analog." Sur-Reply 20 (Ex. 2047, 10:3–8). Patent Owner argues neither Petitioner nor its expert, Dr. Cooperstock, "[ever] explained why it would have been obvious that the amplification and filtering performed by Rosener's signal conditioning circuit would have been digital." *Id*. Patent Owner also argues the examples cited by Petitioner in paragraphs 44, 47, 49, and 50 of Rosener are "are converters, either digital-to-analog or analog-to-digital." *Id*. at 21.

We find Patent Owner's response is persuasive as the cites from Rosener, paragraphs 44, 47, and 50, all involve conversions between analog and digital signals. Sur-Reply 21. It is not disputed that "sound quality enhancement" is being performed by the signal conditioning circuitry of Rosener on analog signals. Figure 9 unannotated clearly shows analog to digital and digital to analog signals processed by a baseband "processor." We are not persuaded that digital-to-analog conversion or analog-to-digital processing would be understood by a person of ordinary skill in the art to be digital processing as performed by a DSP. For example, Petitioner does not show that analog signals of the RF transceiver of Figure 9 are the same as those processed by a "digital signal processor."

As summarized above, we adopt Patent Owner's argument and evidence regarding claim 19. Petitioner has not sufficiently shown that the combination of Rosener and Hankey teaches claim 19 and its dependent claim 20. We need not rely on the Rosener, Hankey, and Dyer combination.

7. Conclusion

We find that the prior art teaches each limitation of claims 1, 2, and 18–20 and that a skilled artisan would have had reason to combine the teachings of Rosner, Hankey, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness are not persuasive. Petitioner has not shown by a preponderance of the evidence that claim 19 and its dependent claim 20 would have been obvious over Rosener and Hankey or over Rosener, Hankey, and Dyer.

E. Obviousness of Claims 3–5 over Rosener, Hankey, and Haupt or Rosener, Hankey, Dyer, and Haupt

Petitioner alleges claims 3–5 would have been obvious over Rosener, Hankey, and Haupt or over Rosener, Hankey, Dyer, and Haupt. Pet. 1, 58–66. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶¶ 135–154.

1. Rosener (Ex. 1004)

Rosener was described in Section III.D.1 above.

2. Hankey (Ex. 1005)

Hankey was described in Section III.D.2 above.

3. Dyer (Ex. 1006)

Dyer was described in Section III.D.3 above.

4. Haupt (Ex. 1020)

Haupt describes "WLAN headphones" to which data (e.g., audio data) can be wirelessly transmitted from a server through an access point. Ex. 1020[19], 2–3. When the headphone is within transmission range of a

[19] Citations are to the native page numbering.

WLAN access point, a connection is made to the server, which permits the headphone to wirelessly receive data from the server. *Id.* at 2.

A private server PS a private sector "connected by a hardwire . . . to an access point APP." Ex. 1020, 6. APP "has a WLAN interface, and communicates wirelessly with a playback device WG located within the transmission range of the access point APP." *Id*. There is also a "public server OS in the public sector" connected wirelessly to the internet. *Id*. "Communication between the playback device WG in the transmission range of the public access point APO and a public or private server OS, PS, takes place wirelessly until reaching the public access point APO, and then takes place via the internet to reach the public server OS or the private server PS." *Id*. at 7.

Haupt also discloses an audio forwarding mode in which a headphone "perform[s] as a local server, providing . . . stored audio files to other playback devices." Ex. 1020, 10. The headphone "can therefore receive data wirelessly from an access point, and then send this data to another playback device." *Id*.

5. Claims 3–5

Claims 3 and 4 depend directly from claim 1 while claim 5 depends from claim 4. We have reviewed Petitioner's showing with respect to claims 3–5. Pet. 58–66. As summarized below, Petitioner has sufficiently shown all the limitations of claims 3–5. Patent Owner does not dispute the showing made on claim 3 or claim 5 beyond the arguments on the claim from which each depends. *See* PO Resp. 46–52 (disputing claim 4).

Claim 3 depends from claim 1 and recites, in pertinent part,

> in a *first operational mode*, the pair of first and second earphones play audio content stored on the mobile, digital audio player and

> transmitted to the first and second earphones from the mobile, digital audio player via the Bluetooth wireless communication links; and in a *second operational mode*, the pair of first and second earphones play audio content streamed from a remote network server." (emphases added).

Petitioner relies on Rosener to teach the "first operational mode," as discussed in above in Section III.D.4.d for limitation 1.d. Pet. 61. Petitioner cites to Haupt's disclosure of "headphones that can receive data from ***a remote network server*** through WLAN communications" for the "second operational mode." *Id.* (citing Ex. 1020, 7–8). Petitioner adds, among other evidence and argument, that "[i]t would have been obvious to a [person of ordinary skill in the art] to incorporate Haupt's techniques and its Bluetooth/WLAN multicommunication-interfaces in Rosener's earphones." *Id.* (citing Ex. 1003 ¶ 135). Petitioner argues the combination "would enable Rosener's earphones to both receive audio from Rosener's disclosed external devices via Bluetooth (in a first operational mode) and audio from Haupt's network server via WLAN communications (in a second operational mode)." *Id.* (citing Ex. 1003 ¶ 135).

Claim 4 depends from claim 1 and recites, in pertinent part

> the processor circuit of the first earphone is for, *upon activation of a user control of the headphones, initiating transmission of a request to a remote network server* that is remote from the mobile, digital audio player and *in communication with* the mobile, digital audio player via a data communication network.

Ex. 1001, 18:56–62 (emphases added). Petitioner cites to Haupt's disclosure of "wireless headphones [with] control buttons ('user control') used to initiate connection to a server." Pet. 65 (citing Ex. 1020, 11–12,

22). Petitioner also alleges "user control" as claimed would have been obvious based on Haupt. *Id.* (citing Ex. 1020, 2–4, 9–13, 22; Ex. 1003 ¶ 150).

Claim 5 depends from claim 4 and recites, in pertinent part, "the processor circuit of the first earphone is further for receiving a response to the request." Petitioner quotes from Haupt as teaching "in order to upload [stored music] to the wireless headphones for playback," "[a] playlist [for stored music] can be compiled on the network server" and then "sent from there to the headphones." Pet. 66 (quoting Ex. 1020, 22). Petitioner also asserts claim 5 would have been obvious to a person of ordinary skill in the art based in part on Haupt's teachings of processing received data from a server. *Id.* (citing Ex. 1003 ¶ 154).

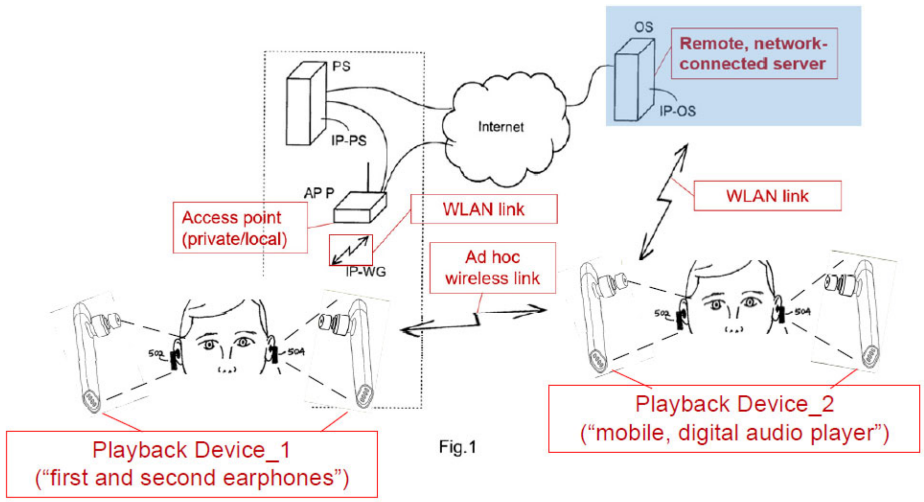
Patent Owner disputes that claim 4 and its dependent claim 5 have been shown to be unpatentable. PO Resp. 46–52. Patent Owner summarizes Petitioner's showing as follows:

> Petitioner's proposed combination is limited, at best, to a system in which the headphones communicate wirelessly with a remote network server (Haupt's PS or OP) to receive digital audio content from that server (per Haupt) and, separately, connects to a mobile DAP (e.g., Rosener's external data source) that provides the digital audio content to the headphones.

Id. at 48. Patent Owner argues that Petitioner "does not explain why Haupt's remote server to which the request is transmitted in Petitioner's proposed Rosener-Hankey-Haupt (-Dyer) combination would be in communication with Rosener's external data source 618." *Id.*

Petitioner argues claim 4 was shown in "the master/slave configuration discussed in the Petition, the headphone recited in claim 4 is mapped to a slave headphone (or Playback Device_1), and the mobile DAP

recited in claim 4 is mapped to a master headphone (or Playback Device_2)." Reply 19 (citing Pet. 61–66). An annotation based on Haupt's figures[20] (Ex. 1003 ¶ 141) is reproduced below.



Annotated schematic showing audio forwarding mode in which one pair of the canalphones (the "master") acts as a mobile, digital audio player for another pair of canalphones.

Pet. 63; Reply 20. Petitioner argues that a person of ordinary skill in the art "would have understood that the master earphone in Haupt is another example of Rosener's data source 618 (which was mapped to mobile DAP in claim 1) because the master earphone is a device that sends audio to another earphone, which is the same function that Rosener lists for data source 618." Reply 20 (citing Ex. 1024 ¶ 43).

Patent Owner responds that the "slave" in Petitioner's master/slave theory

[20] We take notice that the figure also includes the annotated drawing at page 32 of the Petition of the "Rosener-Hankey-Dyer system," illustrating "Playback Device_1" and "Playback Device_2." The annotation is reproduced in Section III.D.4.b above.

> cannot initiate transmission of a request to the server that is connected to the "master." At a minimum, Petitioner never explained how the slave initiates transmission of a request to the server that is communication with the master in light of Haupt's teaching that the server interrupts communications from devices with IP addresses other than the master device.

Sur-Reply 16.

Patent Owner does not cite any evidentiary support for its interruption of communication argument based on Haupt. Haupt explains that "[i]f the IP address of the data receiver is not the IP address IP-WG for the playback device, the respective data transfer *can be interrupted*." Ex. 1020, 7 (emphasis added). If Patent Owner is arguing this excerpt for support, it states that "data transfer" is not necessarily interrupted.

Patent Owner does not respond to the combination of Rosener and Haupt, on which Petitioner relies. Specifically, Petitioner alleges a person of ordinary skill in the art "would have understood that the master earphone in Haupt is another example of Rosener's data source 618." Reply 20. Patent Owner does not dispute, and we find, Haupt and Rosener teach the two operational modes of claim 3. See above Section III.E.5 (re: claim 3). We also find that Haupt discloses "wireless headphones . . . control buttons ('user control') used to initiate connection to a server." Pet. 65 (citing Ex. 1020, 11–12, 22) (emphasis omitted).

Petitioner argues a person of ordinary skill in the art would have had reason to combine Haupt with Rosener and Hankey. One reason is that Rosener's earphones would have been improved by accessing WLAN technology in order for communication over the

Internet to occur. Pet. 59–60 (citing Ex. 1003 ¶¶ 65–66). Patent Owner does dispute the rationale for the combination, citing an institution decision in another *inter partes* review between the same parties on a different patent. PO Resp. 49–52 (citing *Apple Inc. v. Koss Corp.*, IPR2021-00546, Paper 10 at 6–7, 14–16 (PTAB Sept. 7, 2021) ("'546 IPR")).

We agree with Petitioner that the grounds under consideration here are not the same as in the '546 IPR. Reply 21. The '546 IPR challenge included the reference to Seshardri, alleged prior art which is not at issue here. *See* PO Resp. 50. Patent Owner does not explain how Seshardri is relevant here and the argument is not persuasive.

As summarized above, we adopt Petitioner's argument and evidence regarding claims 3–5 as our own findings. Petitioner has sufficiently shown that the combination of Rosener, Hankey, and Haupt or Rosener, Hankey, Haupt, and Dyer teaches claims 3–5.

6. Conclusion

We find that the prior art teaches each limitation of claims 3–5 and that a skilled artisan would have combined the teachings of Rosner, Hankey, Haupt, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness are not persuasive. After considering the complete record, we conclude that Petitioner has shown by a preponderance of the evidence that claims 3–5 would have been obvious over Rosener, Hankey, and Haupt or over Rosener, Hankey, Dyer, and Haupt.

F. Obviousness of Claim 14 over Rosener, Hankey, and Price or Rosener, Hankey, Dyer, and Price

Petitioner alleges claim 14 would have been obvious over Rosener, Hankey, and Price or over Rosener, Hankey, Dyer, and Price. Pet. 1, 67–

72. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶¶ 155–157. Patent Owner disputes the showing on claim 14. PO Resp. 52–57.

1. Rosener (Ex. 1004)

Rosener was described in Section III.D.1 above.

2. Hankey (Ex. 1005)

Hankey was described in Section III.D.2 above.

3. Dyer (Ex. 1006)

Dyer was described in Section III.D.3 above.

4. Price (Ex. 1009)

Price describes a "software updating system" for updating software on electronic devices. Ex. 1009 ¶¶ 37, 7–11. The system includes a "coordinating computer" (or "proxy server"), which is an intermediary device between (i) a server providing software update codes and (ii) one or more devices to be updated using the software update codes. *Id.* ¶¶ 7, 25. The coordinating computer can provide software update codes to each device "without requiring user intervention." *Id.* ¶ 35. One example of software content is "firmware typically stored in an EEPROM." *Id.* ¶ 29.

Figure 1 of Price is reproduced below.

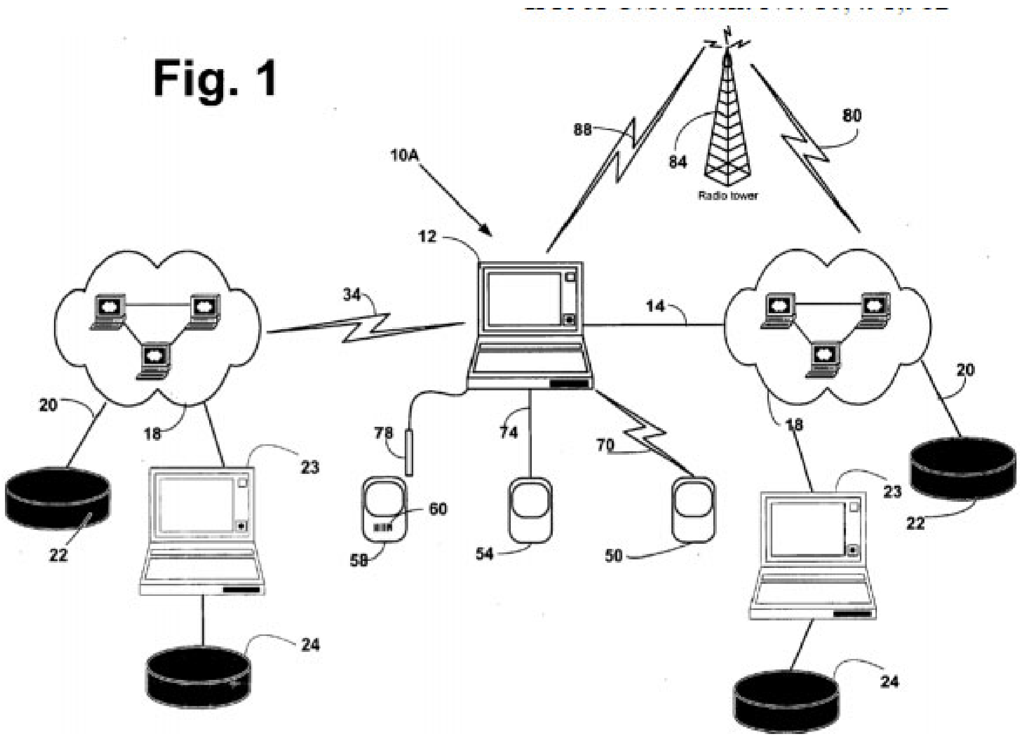


Figure 1 is a schematic of a particular embodiment of Price's system.

Ex. 1009 ¶ 13. Figure 1 illustrates a system 10A, with a coordinating computer 12 is in communication 14 with a network 18 in communication 20 with a network data store 22. *Id.* ¶ 37. Server 23 provides software update codes to computer 12 through network 18 using wired communication 14 or wireless communication 34. *Id.* ¶ 38. Computer 12 then processes the software update codes and delivers them to devices 50, 54, 58. *Id.* ¶ 39. Once the software update codes are delivered, software in devices 50, 54, 58 are updated. *Id.*

5. Claim 14

Claim 14 depends from claim 1 and recites "wherein the processor circuits of the headphones are configured to receive firmware upgrades pushed from a remote network server."

Petitioner alleges that Price describes that "'[c]omplex digital devices' requiring 'microprocessors,' and 'firmware, an operating system, or other device-specific software' benefit from receiving software updates by improving reliability, functionality, or compatibility." Pet. 68–69 (quoting Ex. 1009 ¶¶ 5, 11). According to Petitioner, Rosener's headphones 502, 504 could be configured to "'***receive***' software update code for firmware updates transmitted from a remote server, via a coordinating computer (e.g., computer 12)." *Id.* at 69–71 (regarding Rosener headphones). Further, Petitioner alleges a person of ordinary skill in the art "would have understood that a firmware upgrade is one example of a firmware update and, therefore, would have found it obvious to configure earphones 502, 504 to receive software update code representing '***firmware upgrades***' in order to upgrade the capabilities of earphones 502, 504." *Id.* at 71 (citing Ex. 1003 ¶ 155).

Petitioner argues the combination of Price with Rosener "would have involved applying conventional techniques within the [person of ordinary skill in the art's] skill level." Pet. 70. Petitioner provides, as an example, Price's description "that device 50 can receive software update code from computer 12 using wireless channel communication 70, which coincides with the one or more wireless links Rosener's earphones 502, 504 already have with an external data device." *Id.* (citing Ex. 1003 ¶ 72; Ex. 1004 ¶ 30; Ex. 1009 ¶ 39).

Patent Owner alleges that "updating a device's firmware requires that the device be sufficiently powered throughout the firmware upgrade process." PO Resp. 53 (citing Ex. 2038 ¶ 70). Patent Owner acknowledges Hankey's earpiece downloads updates but requires power from an external

power supply. *Id*. (citing Ex. 1005 ¶¶ 182–188). According to Patent Owner "Hankey does not disclose using the earpiece's battery to power the earpiece during a firmware upgrade and Rosener does not disclose a way to connect to an external power supply." *Id*. at 53–54. Patent Owner argues Rosener's earphones would have to be modified to include a power source, i.e., a battery, which would be beyond the level of ordinary skill determined previously. *Id*. at 54. Patent Owner notes that none of the other references in this challenge address this power issue, resulting in no expectation of success from the combination. *Id*. at 55–56.

We agree with Petitioner that the argument Patent Owner makes is not supported by the evidence. Reply 24. Furthermore, as Petitioner argues, a person of ordinary skill in the art "would have understood how to implement configuration options that would have addressed any power consumption issues associated with firmware upgrades." *Id*. (citing Ex. 1024 ¶¶ 49–50).

Patent Owner's argument is predicated on bodily incorporating a battery into Hankey or Rosener's earpieces. As already stated, how to put together a device based on the combined references is not required in order to find a claim obvious. *In re Keller*, 642 F.2d at 425. In addition, Patent Owner did not dispute that Rosener and Hankey taught a "rechargeable power source," limitation 1.c.v. *See* Section III.D.4.d (limitation 1.c.v above). Claim 14 itself does not recite a power source. All that is required by claim 14 is that "the headphones are configured to receive firmware upgrades pushed from a remote network server." How the firmware is "pushed" is left to the understanding of a person of ordinary skill in the art and is not directly recited.

Patent Owner attempts to distinguish "charging" from "powering during use." Sur-Reply 16–17 (emphasis omitted). Other than timing, we are not persuaded there is a difference and Patent Owner does not support its argument with evidence. Patent Owner's responses to Petitioner's other arguments, "conditional or incremental firmware upgrades" and improper incorporation "system-on-chip (SOC)" from the written disclosure into the claims of the '982 patent, do not persuade us that our determination is erroneous. *See* Sur-Reply 17–18.

We find that the prior art teaches each limitation of claim 14 and that a skilled artisan would have combined the teachings of Rosner, Hankey, Price, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness are not persuasive. After considering the complete record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 14 would have been obvious over Rosener, Hankey, and Price or over Rosener, Hankey, Dyer, and Price.

G. Obviousness of Claim 15 over Rosener, Hankey, and Paulson or Rosener, Hankey, Dyer, and Paulson

Petitioner alleges claim 15 would have been obvious over Rosener, Hankey, and Paulson or over Rosener, Hankey, Dyer, and Paulson. Pet. 1, 72–75. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶¶ 158–159. Patent Owner disputes that claim 15 would have been obvious. PO Resp. 57–60.

1. Rosener (Ex. 1004)

Rosener was described in Section III.D.1 above.

2. Hankey (Ex. 1005)

Hankey was described in Section III.D.2 above.

3. Dyer (Ex. 1006)

Dyer was described in Section III.D.3 above.

4. Paulson (Ex. 1010)

Paulson describes a "two-way voice communication device" with a "switch supporting a push-to-talk" operation. Ex. 1010, 2:51–67. The device includes "earphone assembly 105" with housing 110 and microphone 130 located at one end of boom 120. *Id.* at 5:1–13, Fig. 1B.

Paulson describes that an "electrical signal from a microphone" (e.g., microphone 130) can be "carried on conductors 343 and 344." Ex. 1010, 6:17–19, Fig. 3. Paulson also describes that "switch 330 may be arranged to provide push-to-talk functionality." *Id.* at 6:43–44. "When activated, switch 330 may stop the electrical signals of microphone 130 from reaching the designated conductors of multi-conductor cable 350, effectively muting microphone 130." *Id.* at 6:30–33.

5. Claim 15

Limitation 15.1 of claim 15, which depends from claim 1, recites "wherein the processor circuit of the first earphone is configured to: process audible utterances by the user picked by the microphone in response to activation of the microphone by the user." Pet. 74. Petitioner contends that Rosener's earphones 502, 504 include "a microphone to collect '***audible utterances by the user***.'" *Id*. (quoting Ex. 1004 ¶ 56). Petitioner argues Paulson's teaching that a switch is "important for users in a noisy environment, to allow [users] to reduce the noise heard by [a] distant party." *Id.* at 73–74 (citing Ex. 1010, 6:33–49; Ex.1003 ¶ 76).

Limitation 15.2 of claim 15 recites "transmit a communication based on the audible utterances via the Bluetooth wireless communication links."

Pet. 75. Petitioner cites Rosener's teaching that "earphones 502, 504 can provide 'two-way communications between a user and an external data device (e.g., a cellular telephone),' e.g., via Bluetooth connections." Pet. 75 (citing Ex. 1004 ¶¶ 11, 35). According to Petitioner, a person of ordinary skill in the art "would have understood that earphones 502, 504 would have been configured to provide two-way communications with an external device using Bluetooth connections ('***Bluetooth wireless communication links***') such that audio generated by a user's voice ('***communication based on the audible utterances***') are transmitted from earphones 502, 504 to the cellular telephone." *Id.* at 75 (citing Ex. 1004 ¶ 50; Ex. 1003 ¶ 159).

Patent Owner argues that Paulsen's earphone is not wireless. PO Resp. 58 (citing Ex. 1010, Fig. 3 (switch 330); Ex. 2038 ¶ 85). Patent Owner argues Petitioner has not shown "how Paulson's pressure-actuated, mechanical switch would be implemented into Rosener's small form factor earphones. Mechanical switches are typically larger in size than solid-state or MEMS (microelectromechanical systems) switches because mechanical switches have (non-micro) moving parts." *Id*. at 59 (citing Ex. 2038 ¶ 87). Again, Patent Owner argues such an implementation would be beyond the level of ordinary skill we have determined for the '982 patent in this proceeding. *Id*. at 59–60 (citing, *inter alia*, Ex. 2038 ¶ 87).

Bodily incorporation is not required in order to meet the test of obviousness. *In re Keller*, 642 F.2d at 425. Petitioner's argument is in accord, arguing, as we also find, Paulson's mechanical button "does not mean that [a person of ordinary skill in the art] would have had to physically incorporate the exact mechanical button from Paulson into Rosener-Hankey earphone." Reply 24–25 (citing Ex. 1024 ¶¶ 53–54).

Petitioner argues a person of ordinary skill in the art "reading Paulson would get the idea of incorporating the push-to-talk button to Hankey's device." Reply 24 (citing Ex. 1024 ¶¶ 53–54). Patent Owner argues that the "button" would provide the idea recited in claim 15 raises a new argument not presented in the Petition. Sur-Reply 19. We disagree. The argument was a response to the argument raised in pages 59 through 60 of Patent Owner's Response. Patent Owner does not respond to the bodily incorporation argument made by Petitioner. We find that bodily incorporation is dispositive of the positions raised by Patent Owner.

6. Conclusion

We find that the prior art teaches each limitation of claim 15 and that a skilled artisan would have combined the teachings of Rosner, Hankey, Paulson, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness are not persuasive. After considering the complete record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 15 would have been obvious over Rosener, Hankey, and Paulson or over Rosener, Hankey, Dyer, and Paulson.

H. Obviousness of Claims 16 and 17 over Rosener, Hankey, and Huddart or Rosener, Hankey, Dyer, and Huddart

Petitioner alleges claims 16 and 17 would have been obvious over Rosener, Hankey, and Huddart or over Rosener, Hankey, Dyer, and Huddart. Pet. 1, 76–82. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶ 160. Patent Owner does not dispute Petitioner's showing regarding claims 16 and 17.

1. Rosener (Ex. 1004)

Rosener was described in Section III.D.1 above.

2. Hankey (Ex. 1005)

Hankey was described in Section III.D.2 above.

3. Dyer (Ex. 1006)

Dyer was described in Section III.D.3 above.

4. Huddart (Ex. 1007)

Huddart describes a wireless stereo system that includes a headset component and a wireless earbud component. Ex. 1007, 2:13–15. Headset 4 communicates with electronic device 2 over a wireless communication link 12. *Id.* at 2:52–3:6. During a "stereo listening operation," wireless earbud 6 is used in conjunction with headset 4 through wireless communication link 18. *Id.* at 3:7–18. In this mode, headset 4 and earbud 6 can be used in conjunction for stereo listening from "a cellular telephone 100, digital music player 106," among other electronic devices. *Id.* at 7:62–8:8.

Huddart describes embodiments in which the wireless stereo system includes a "charger/carrier" with "a small plastic storage case for storing headset 4 and wireless earbud 6 for protection and charging." Ex. 1007, 8:25–27. The charger/carrier includes "a battery and charger circuit for charging both the headset battery and wireless earbud battery when inserted into the . . . charger/carrier." *Id.* at 8:27–31. The charger/carrier can be pocket size, providing "a convenient mechanism" to charge the batteries frequently. *Id*. at 8:31–33. Since the earbud can have "a relatively small[] capacity battery due to its limited size," the pocket charger/carrier provides the convenience of frequent charging of the earbud "in the absence of a primary charger." *Id*. at 8:31–34. The pocket charger/carrier is portable. *Id*. "The primary charger may be a cable or docking facility connecting the

pocket charger/carrier to a wall outlet or [a] primary batter[y]" to allow a storage case battery on the pocket charger/carrier to be charged. *Id*. at 8:52–57.

The charger/carrier is capable of charging the earbud's and the headset's batteries wirelessly. Ex. 1007, 8:37–40. As a result, "the earbud advantageously does not require charging contacts on its small exterior surface when charging is performed with inductive charging." *Id.*

5. Claims 16 and 17

Claim 16 depends from claim 1 and recites "wherein the rechargeable power source comprises a wirelessly chargeable circuit." Huddart teaches a wireless battery and enabling circuitry. Ex. 1007, 8:35–50. Petitioner relies on this teaching to show claim 16. Pet. 80 (citing Ex. 1007, 8:35–50; Ex. 1003 ¶ 160).

Claim 17 depends from claim 1 and recites "wherein the rechargeable power source comprises a passive, wireless rechargeable power source." Petitioner argues "passive" is described in a prior art United States patent and is "not inventive." Pet. 80–81 (citing Ex. 1001, 7:7–9 (referencing US Patent No. 7,027,311 toVanderelli (Ex. 1012); *see also* Section III.I.5 (describing Vanderelli).

According to Petitioner, a person of ordinary skill in the art would have looked to Huddart "to reduce the number of components needed on the surface area of small compact Rosener-Hankey/Rosener-Hankey-Dyer earphones," thus "eliminating the charging contacts on the surface of the earphones." Pet. 78 (citing Ex. 1003 ¶¶ 81–82; Ex. 1007, 8:38–45).

We find that the prior art teaches each limitation of claims 16 and 17 and that a skilled artisan would have combined the teachings of Rosner,

Hankey, Huddart, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness is not persuasive. After considering the complete record, we conclude that Petitioner has shown by a preponderance of the evidence that claims 16 and 17 would have been obvious over Rosener, Hankey, and Huddart or over Rosener, Hankey, Dyer, and Huddart.

I. Obviousness of Claim 17 over Rosener, Hankey, Huddart, and Vanderelli or Rosener, Hankey, Dyer, Huddart, and Vanderelli

Petitioner alleges claim 17 would have been obvious over Rosener, Hankey, Huddart, and Vanderelli or over Rosener, Hankey, Dyer, Huddart, and Vanderelli. Pet. 1, 82–85. Petitioner also relies on the Cooperstock Declaration. Ex. 1003 ¶¶ 166–167. Patent Owner does not dispute Petitioner's showing regarding claim 17.

1. Rosener (Ex. 1004)

Rosener was described in Section III.D.1 above.

2. Hankey (Ex. 1005)

Hankey was described in Section III.D.2 above.

3. Dyer (Ex. 1006)

Dyer was described in Section III.D.3 above.

4. Huddart (Ex. 1007)

Huddart was described in Section III.H.4 above.

5. Vanderelli (Ex. 1012)

Vanderelli describes circuitry for wireless charging that converts radiation energy obtained from "a range of RF radiation" into direct current (DC) output. Ex. 1012, 1:40–45, Fig. 1.

The circuitry includes antenna 12 for receiving RF radiation and inductor 18 for converting RF radiation into a storable form. Ex. 1012, 2:1–58. To allow energy to be obtained from a range of frequencies,

inductor 18 is divided into taps 20, which are calculated to match "the inductor's impedance to [the] desired RF range." *Id.* Diodes 26 direct converted energy to capacitors C1–Cx, where the energy is stored as DC voltage. *Id.* "The sum of the voltages available from C1–Cx is stored in any storage device 28 such as a capacitor [and is] made available for immediate use." *Id.* at 4:9–17

6. Claim 17

Claim 17 is described above in Section III.H. With respect to Vanderelli, Petitioner argues it would be added to the combination "to thereby enjoy advantages of obtaining energy from a range of RF frequencies." Pet. 85. "[T]he resulting system would have provided earphones 502, 504, each with a rechargeable power source that may comprise capacitors passively charged with RF radiation ('***passive, wireless rechargeable power source***')." *Id.* (citing Ex. 1003 ¶ 167).

We find that the prior art teaches each limitation of claim 17 and that a skilled artisan would have combined the teachings of Rosner, Hankey, Huddart, Vanderelli, and Dyer. As explained below, Patent Owner's objective indicia of nonobviousness are not persuasive. After considering the complete record, we conclude that Petitioner has shown by a preponderance of the evidence that claim 17 would have been obvious over Rosener, Hankey, Huddart, and Vanderelli or over Rosener, Hankey, Dyer, Huddart, and Vanderelli.

J. Objective Indicia of Nonobviousness

Patent Owner argues that the sales of Petitioner's AirPods and AirPods Pro products (collectively "AirPods Products") have achieved significant sales and are thus evidence of commercial success that confirms

that the ’982 patent claim 1 would not have been obvious. PO Resp. 41 (citing Ex. 2044[21], 15). Patent Owner also alleges that dependent claims 4, 5, 14, 15, 19, and 20 are embodied by commercially successful products based on “record evidence” showing that the AirPods Products “when used with an iPhone as the mobile DAP, possess the elements of these claims.” *Id*. at 65 (citing Ex. 1014[22], 1018–1019,1033–1035, 1038–1039, 1056–1057, 1071–1073, 1076–1077).

Notwithstanding what the teachings of the prior art would have suggested to one skilled in the art, objective evidence of non-obviousness (so called “secondary considerations”) may lead to a conclusion that the challenged claims would not have been obvious. *In re Piasecki*, 745 F.2d 1468, 1471–72 (Fed. Cir. 1984). Objective evidence of non-obviousness “may often be the most probative and cogent evidence in the record” and “may often establish that an invention appearing to have been obvious in light of the prior art was not.” *Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling USA, Inc.*, 699 F.3d 1340, 1349 (Fed. Cir. 2012) (quoting *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983)). Objective evidence may include long-felt but unsolved need, failure of others, unexpected results, commercial success, copying, licensing, and praise. *See Graham*, 383 U.S. at 17–18; *Leapfrog Enters., Inc. v. Fisher–Price, Inc.*, 485 F.3d 1157, 1162 (Fed. Cir. 2007).

Commercial success is typically shown with evidence of “significant sales in a relevant market.” *Ormco Corp. v. Align Tech., Inc.*, 463 F.3d

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[21] Available at https://www.businessofapps.com/data/apple-statistics/
[22] District Court Lawsuit, “Plaintiff Koss Corporation’s Preliminary Infringement Contentions” (Ex. 1014).

1299, 1312 (Fed. Cir. 2006) (citation omitted). "When a patentee can demonstrate commercial success, usually shown by significant sales in a relevant market, and that the successful product is the invention disclosed and claimed in the patent, it is presumed that the commercial success is due to the patented invention." *J.T. Eaton & Co. v. Atlantic Paste & Glue Co.*, 106 F.3d 1563, 1571 (Fed. Cir. 1997).

To give substantial weight to objective indicia of nonobviousness such as commercial success, a proponent must establish a nexus between the evidence and the merits of the claimed invention. *ClassCo, Inc. v. Apple, Inc.*, 838 F.3d 1214, 1220 (Fed. Cir. 2016). Nexus is a legally and factually sufficient connection between the objective evidence and the claimed invention, such that the objective evidence should be considered in determining non-obviousness. *Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988). "[T]here is no nexus unless the evidence presented is 'reasonably commensurate with the scope of the claims.'" *ClassCo*, 838 F.3d at 1220 (quoting *Rambus Inc. v. Rea*, 731 F.3d 1248, 1257 (Fed. Cir. 2013)). A patentee is entitled to a presumption of nexus "when the patentee shows that the asserted objective evidence is tied to a specific product and that product 'embodies the claimed features, and is coextensive with them.'" *Fox Factory, Inc. v. SRAM, LLC*, 944 F.3d 1366, 1373 (Fed. Cir. 2019) (quoting *Polaris Indus., Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1072 (Fed. Cir. 2018)). "[T]he patentee retains the burden of proving the degree to which evidence of secondary considerations tied to a product is attributable to a particular claimed invention." *Fox Factory*, 944 F.3d at 1378. The Federal Circuit has held that "if the marketed product embodies the claimed features, and is

coextensive with them, then a nexus is presumed and the burden shifts to the party asserting obviousness to present evidence to rebut the presumed nexus." *Brown & Williamson Tobacco Corp. v. Philip Morris Inc.*, 229 F.3d 1120, 1130 (Fed. Cir. 2000).

"[T]he purpose of the coextensiveness requirement is to ensure that nexus is only presumed when the product tied to the evidence of secondary considerations is the invention disclosed and claimed." *Lectrosonics, Inc. v. Zaxcom, Inc.*, IPR2018-01129, Paper 33 at 32 (PTAB Jan. 24, 2020) (precedential) (citing *Fox Factory*, 944 F.3d at 1374) (emphasis and internal quotation marks omitted) (alteration in original). "[T]he degree of correspondence between a product and the patent claim falls along a spectrum. At one end of the spectrum lies perfect or near perfect correspondence. At the other end lies no or very little correspondence." *Id.* (alteration in original). Also, "[a] patent claim is not coextensive with a product that includes a 'critical' unclaimed feature that is claimed by a different patent and that materially impacts the product's functionality." *Id.* (citing *Fox Factory*, 944 F.3d at 1375).

"A finding that a presumption of nexus is inappropriate does not end the inquiry into secondary considerations"; rather, "the patent owner is still afforded an opportunity to prove nexus by showing that the evidence of secondary considerations is the 'direct result of the unique characteristics of the claimed invention.'" *Fox Factory*, 994 F.3d at 1374 (quoting *In re Huang*, 100 F.3d 125, 140 (Fed. Cir. 1996)).

"Ultimately, the fact finder must weigh the [objective indicia] evidence presented in the context of whether the claimed invention as a whole would have been obvious to a skilled artisan." *See Lectrosonics*,

Paper 33 at 33 (citing *WBIP, LLC v. Kohler Co.*, 829 F.3d 1317, 1331–32 (Fed. Cir. 2016)).

As evidence of commercial success, Patent Owner relies on public sources to estimate that Petitioner sold: 15 million AirPods in 2017; 35 million AirPods in 2018; 60 million AirPods in 2019; and 114 million AirPods in 2020. PO Resp. 41 (citing Ex. 2044[23], 15). Patent Owner argues that "[a]t $159 USD apiece, that amounts to more than $35 billion in sales in four years. This estimate is exceedingly great because the AirPod[s] Products dominate the market for 'true wireless' stereo headphones." *Id*. at 43 (citing Ex. 2046[24], 1). Patent Owner also alleges the market for wireless headphones is growing, "which is an important component of . . . commercial success.'" *Id*. at 43–44 (citing Ex. 2046, 2; *In re Applied Materials, Inc*., 692 F.3d 1289, 1300 (Fed. Cir. 2012)).

Patent Owner argues that nexus exists between the AirPods Products and claim 1 based on a November 6, 2020, infringement claim chart, comparing the AirPods Products to the '982 patent claims, that it had submitted in the District Court Lawsuit. PO Resp. 44 (citing Ex.1014, 1003–1014 (AirPods Pro), 1041–1052 (AirPods)). Patent Owner also relies on the instructions to "Connect your AirPods and AirPods Pro to your iPhone." *Id.* at 42–44 (citing Ex. 2045[25], 1). Patent Owner does not provide a detailed comparison of the AirPods with the challenged claims in its Response. *Id*. at 44–45. Nevertheless, Petitioner does not contest, in this

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[23] *Available at* https://www.businessofapps.com/data/apple-statistics/.
[24] *Available at* https://9to5mac.com/2021/01/27/airpods-dominate-wireless-headphone-market/.
[25] *Available at* https://support.apple.com/en-us/HT207010.

proceeding at least, that its products meet all the claim limitations.
Tr. 66:11–26.

Petitioner argues that Patent Owner has failed to meet its burden to establish nexus, because Patent Owner has not shown the required coextensiveness between the AirPods Products and the claims. Reply 30. Petitioner argues that Patent Owner does not allege the coextensiveness aspect of nexus. *Id*. Petitioner argues the evidence of nexus is based on a "subset of features recited in claim 1" and the setup process for the AirPods Products. *Id*. at 31 (citing PO Resp. 43–44). Petitioner concludes by arguing the allegations are conclusory and fail to establish a prima facie nexus. *Id*. (citing *Demaco Corp. v. F. Von Langsdorff Lic. Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988)).

Petitioner also lists several unclaimed features of the AirPods products including:

> (a) the first-generation AirPods had sensors that "detect when AirPods are in ear and can automatically play and pause music" [Ex. 2040], (b) the second generation AirPods had a proprietary system-in-package (SiP) chip (Apple H1 chip) that delivered "performance efficiencies, faster connect times, more talk time" [Ex. 2041], (c) the AirPods Pro had adaptive noise cancelling feature that "uses two microphones" on a single earphone "combined with advanced software. to continuously adapt to each individual ear and headphone fit" [Ex. 2042], and (d) all AirPods Products "feature the same great battery life . . . with up to five hours of listening time" [Ex. 2042].

Reply 31–32; *see also id*. at 32 (citing Ex. 1025, 240:12–15 (Mr. McAlexander testifying as to other unclaimed features of the AirPods Products)).

Petitioner also argues Patent Owner's evidence does not demonstrate commercial success that results directly from the "unique characteristics" of the claimed invention. Reply 32 (citing *In re Huang*, 100 F. 3d 135, 140 (Fed. Cir. 1996)).

In response, Patent Owner alleges it need not prove the claims are coextensive with the AirPods Products where there is proof "that ***the patentee demonstrate[s] that the product is essentially the claimed invention***." Sur-Reply 22–23 (citing *FOX Factory*, 944 F.3d at 1374). Notwithstanding the preceding argument, Patent Owner contends "several" of the alleged unclaimed features are claimed. *Id*. at 23. As an example, Patent Owner cites unclaimed feature (b) above from the Reply, the "(SiP) chip (Apple H1 chip)," arguing claim 1 recites a "processor circuit." *Id.* at 23. Patent Owner also argues claim 1 recites a "rechargeable battery," as meeting the alleged "great battery life" of unclaimed feature (d) above. *Id*. Noise cancelling is identified in unclaimed feature (c) above and is argued as the "sound quality enhancement" of claim 19. *Id*. Patent Owner argues it has shown three of the four unclaimed features are claimed. *Id*.

We find that Patent Owner has not met its burden of showing the requisite nexus — that the AirPods Products embody "the claimed features, and is coextensive with them." *Fox Factory*, 944 F.3d at 1373. Patent Owner's sole basis for asserting that the AirPods Products embody the claims is a claim chart from a separate litigation. Ex. 1014, 1003–1014, 1041–1052.

In any case, we agree with Petitioner that the Response did not allege the AirPods Products are coextensive with any claim. Reply 30. Further, Patent Owner misapprehends *Fox Factory* in alleging coextensiveness is

not required. *See Fox Factory*, 944 F.3d at 1376 ("On a broader note, if we were to agree . . . that the coextensiveness requirement is met so long as the patent claim broadly covers the product that is the subject of the secondary considerations evidence, irrespective of the nature of any unclaimed features — then the coextensiveness requirement would rest entirely on minor variations in claim drafting."). Moreover, we are not persuaded that the alleged unclaimed features, (a) through (d) of the Reply, are claimed. Patent Owner treats the claim language too broadly. Beyond attorney argument, we are not presented with proof that a "processor circuit" is coextensive with a chip is used on the AirPods to enhance "performance efficiencies, faster connect times, more talk time." Similarly, "great battery life" is not swallowed up by a claim limitation to a "rechargeable battery." Neither do we agree that Patent Owner has sufficiently shown that "sound quality enhancement" is noise cancellation.

Moreover, the question is whether the unclaimed features "materially impact the functionality of the . . . products." *Fox Factory*, 944 F.3d at 1376. *Fox Factory* did not hold that unclaimed features must be critical to or for improving the heart of the challenged claims. Rather, we look to whether the unclaimed features "materially impact[] the product's functionality." *Id.* at 1375. Thus, when *Fox Factory* states that "if the unclaimed features amount to nothing more than additional insignificant features, presuming nexus may nevertheless be appropriate," *id.* at 1374, it means insignificant to the product, not insignificant to the challenged claims. Patent Owner does not argue, and has not presented evidence, that the unclaimed features of AirPods Products are insignificant to, or do not materially impact, the AirPods Products. In sum, Patent Owner has not

shown nexus by virtue of the claims being coextensive with the allegedly successful products.

As noted above, Patent Owner may still show nexus by showing that the commercial success of AirPods Products is the direct result of the unique characteristics of the claimed invention. *See Fox Factory*, 944 F.3d at 1373–1374; *Huang*, 100 F.3d at 140. Although Patent Owner cites case law regarding nexus based on unique characteristics of the claimed invention, it does not argue what the characteristics are or provide supporting evidence. *See* PO Resp. 42–43 (citing *Demaco,* 851 F.2d at 1392; *Fox Factory,* 994 F.3d at 1373–1374).

Because Patent Owner has not shown a nexus between the claimed invention and the alleged commercial success, Patent Owner has not made a persuasive showing that commercial success evidences non-obviousness.

IV. CONCLUSION[26]

For the reasons discussed above, Petitioner has shown by a preponderance of the evidence that claims 1–5 and 14–18 of the ’982 patent are unpatentable as summarized in the table below. Petitioner has not shown that challenged claims 19 and 20 are unpatentable.

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[26] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner’s attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding.* *See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. §§ 42.8(a)(3), (b)(2).

In summary:

Claims	**35 U.S.C. §**	**Reference(s)/Basis**	**Claims Shown Unpatentable**	**Claims Not Shown Unpatentable**
1, 2, 18–20	103	Rosener, Hankey or Rosener, Hankey, Dyer	1, 2, 18	19, 20
3–5	103	Rosener, Hankey, Haupt or Rosener, Hankey, Dyer, Haupt	3–5	
14	103	Rosener, Hankey, Price or Rosener, Hankey, Dyer, Price	14	
15	103	Rosener, Hankey, Paulson or Rosener, Hankey, Dyer, Paulson	15	
16, 17	103	Rosener, Hankey, Huddart or Rosener, Hankey, Dyer, Huddart	16, 17	
17	103	Rosener, Hankey, Huddart, Vanderelli or Rosener, Hankey, Dyer, Huddart, Vanderelli	17	
Overall Outcome			1–5, 14–18	19, 20

V. Order

In consideration of the foregoing, it is hereby:

ORDERED that Petitioner has shown that challenged claims 1–5 and 14–18 are unpatentable;

FURTHER ORDERED that Petitioner has not shown that challenged claims 19 and 20 are unpatentable; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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US010506325B1

(12) **United States Patent**
Koss et al.

(10) **Patent No.: US 10,506,325 B1**
(45) **Date of Patent: *Dec. 10, 2019**

(54) **SYSTEM WITH WIRELESS EARPHONES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/528,703**

(22) Filed: **Aug. 1, 2019**

Related U.S. Application Data

(63) Continuation of application No. 16/375,879, filed on Apr. 5, 2019, which is a continuation of application
(Continued)

(51) **Int. Cl.**
H04R 1/10 (2006.01)
H04W 48/20 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04R 1/1041*** (2013.01); ***H03G 3/02*** (2013.01); ***H03K 17/9622*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04R 2201/107; H04R 1/02; H04R 5/033
(Continued)

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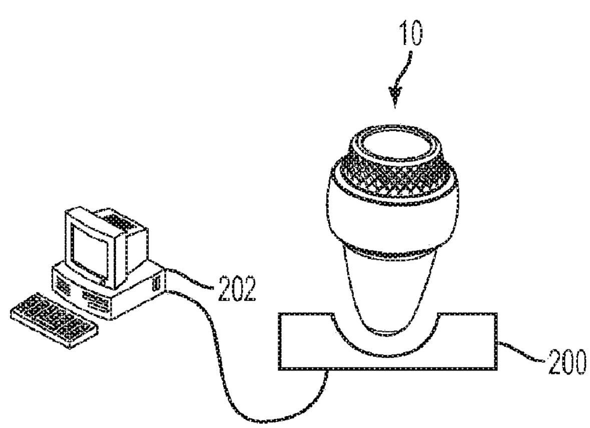
(74) *Attorney, Agent, or Firm* — K&L Gates LLP

(57) **ABSTRACT**

Apparatus comprises adapter and speaker system. Adapter is configured to plug into port of personal digital audio player. Speaker system is in communication with adapter, and comprises multiple acoustic transducers, programmable processor circuit, and wireless communication circuit. In first operational mode, processor circuit receives, via adapter, and processes digital audio content from personal digital audio player into which adapter is plugged, and the multiple acoustic transducers output the received audio content from the personal digital audio player. In second operational mode, wireless communication circuit receives digital audio content from a remote digital audio source over a wireless network, processor circuit processes the digital audio content received from remote digital audio source, and the multiple acoustic transducers output the audio content received from the remote digital audio source.

18 Claims, 16 Drawing Sheets



APPLE 1001

Related U.S. Application Data

No. 16/182,927, filed on Nov. 7, 2018, now Pat. No. 10,368,155, which is a continuation of application No. 15/962,305, filed on Apr. 25, 2018, now Pat. No. 10,206,025, which is a continuation of application No. 15/650,362, filed on Jul. 14, 2017, now Pat. No. 9,986,325, which is a continuation of application No. 15/293,785, filed on Oct. 14, 2016, now Pat. No. 9,729,959, which is a continuation of application No. 15/082,040, filed on Mar. 28, 2016, now Pat. No. 9,497,535, which is a continuation of application No. 14/695,696, filed on Apr. 24, 2015, now Pat. No. 9,438,987, which is a continuation of application No. 13/609,409, filed on Sep. 11, 2012, now Pat. No. 9,049,502, which is a continuation of application No. 13/459,291, filed on Apr. 30, 2012, now Pat. No. 8,571,544, which is a continuation of application No. 12/936,488, filed as application No. PCT/US2009/039754 on Apr. 7, 2009, now Pat. No. 8,190,203.

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(51) **Int. Cl.**

H04M 1/02	(2006.01)
H04R 3/00	(2006.01)
H04R 5/033	(2006.01)
H04R 5/04	(2006.01)
H03G 3/02	(2006.01)
H04R 1/02	(2006.01)
H04L 29/12	(2006.01)
H04H 20/95	(2008.01)
H03K 17/96	(2006.01)
H04W 4/80	(2018.01)
H04W 84/12	(2009.01)
H04W 84/18	(2009.01)
H04R 25/00	(2006.01)

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CPC ***H04H 20/95*** (2013.01); ***H04L 61/6068*** (2013.01); ***H04M 1/0254*** (2013.01); ***H04R 1/02*** (2013.01); ***H04R 1/1091*** (2013.01); ***H04R 3/00*** (2013.01); ***H04R 5/033*** (2013.01); ***H04R 5/04*** (2013.01); ***H04W 4/80*** (2018.02); ***H04W 48/20*** (2013.01); *H03K 2217/960785* (2013.01); *H04R 25/554* (2013.01); *H04R 2201/103* (2013.01); *H04R 2201/107* (2013.01); *H04R 2225/55* (2013.01); *H04R 2420/07* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01)

(58) **Field of Classification Search**

USPC 381/74, 380, 375, 364, 381; 455/42, 557, 455/41.3, 573, 466, 569.1, 553.1

See application file for complete search history.

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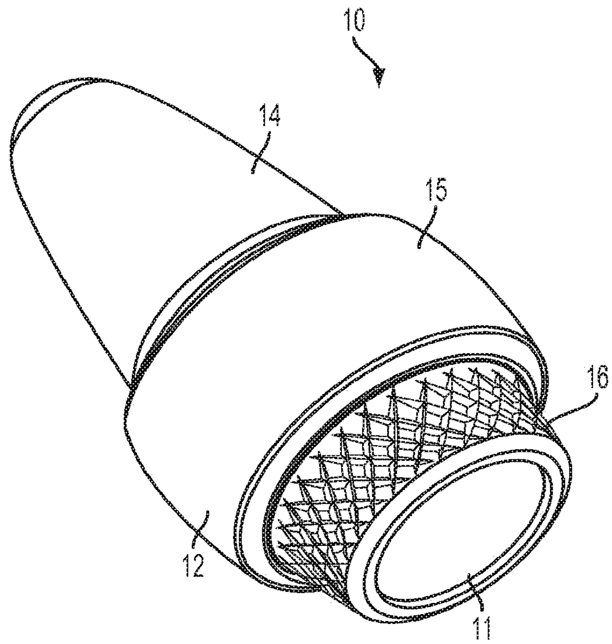

FIG. 1A

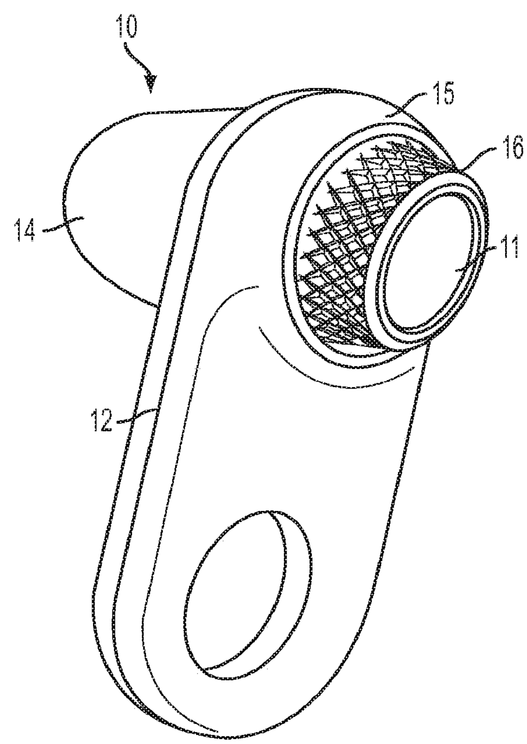

FIG. 1B

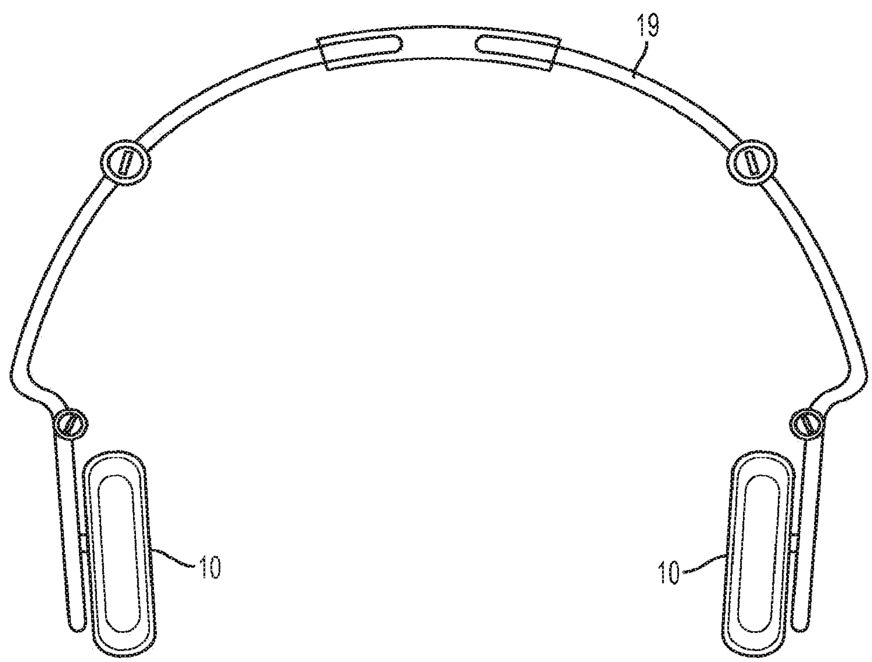

FIG. 1C

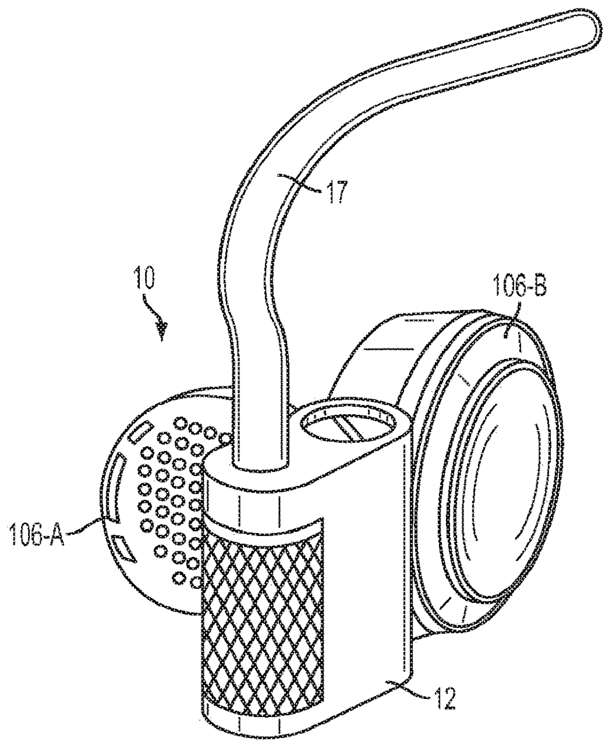

FIG. 1D

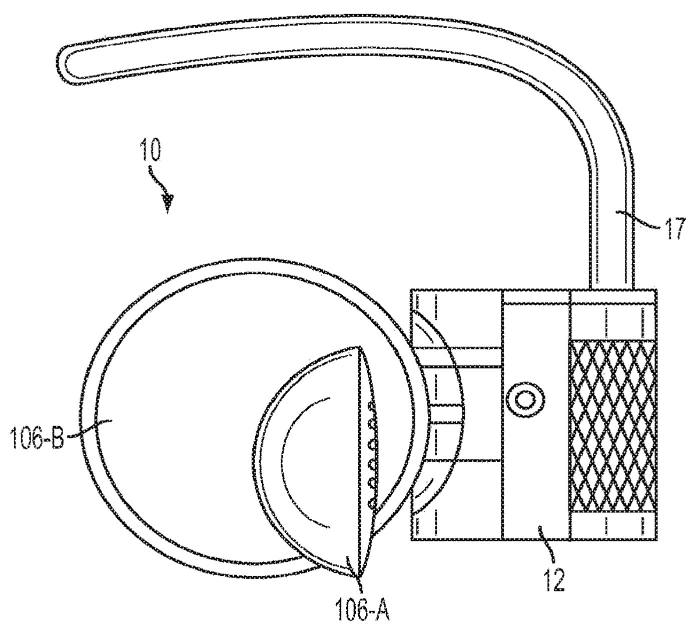

FIG. 1E

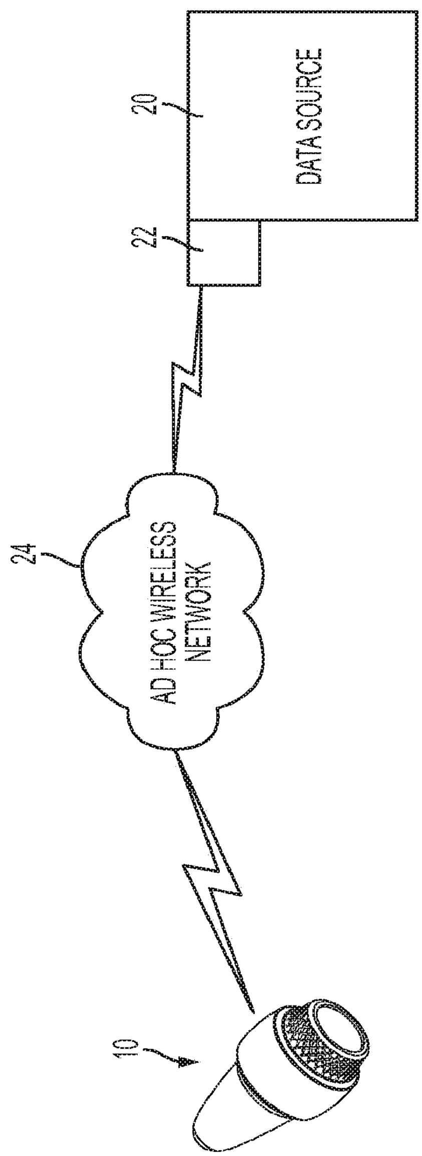

FIG. 2A

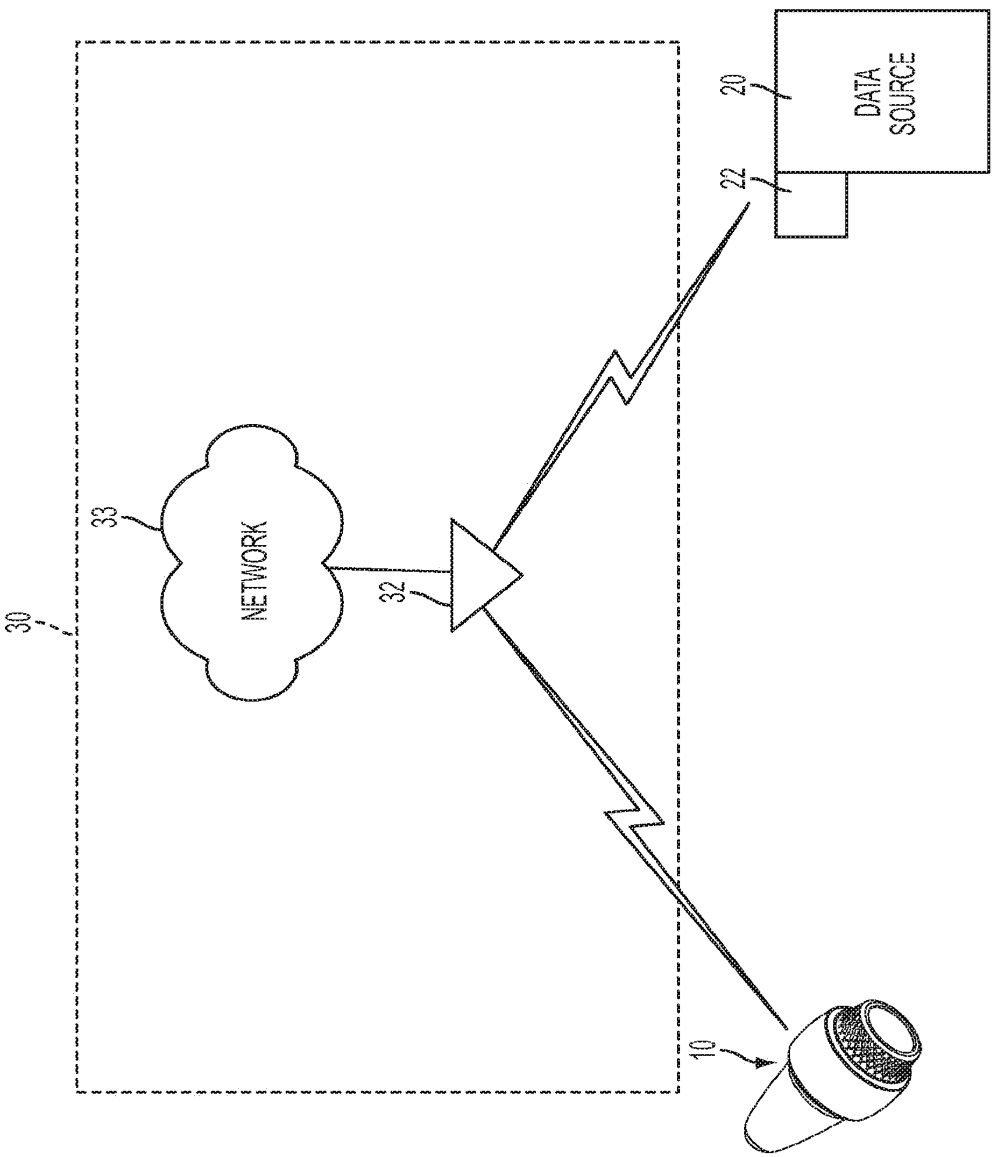

FIG. 2B

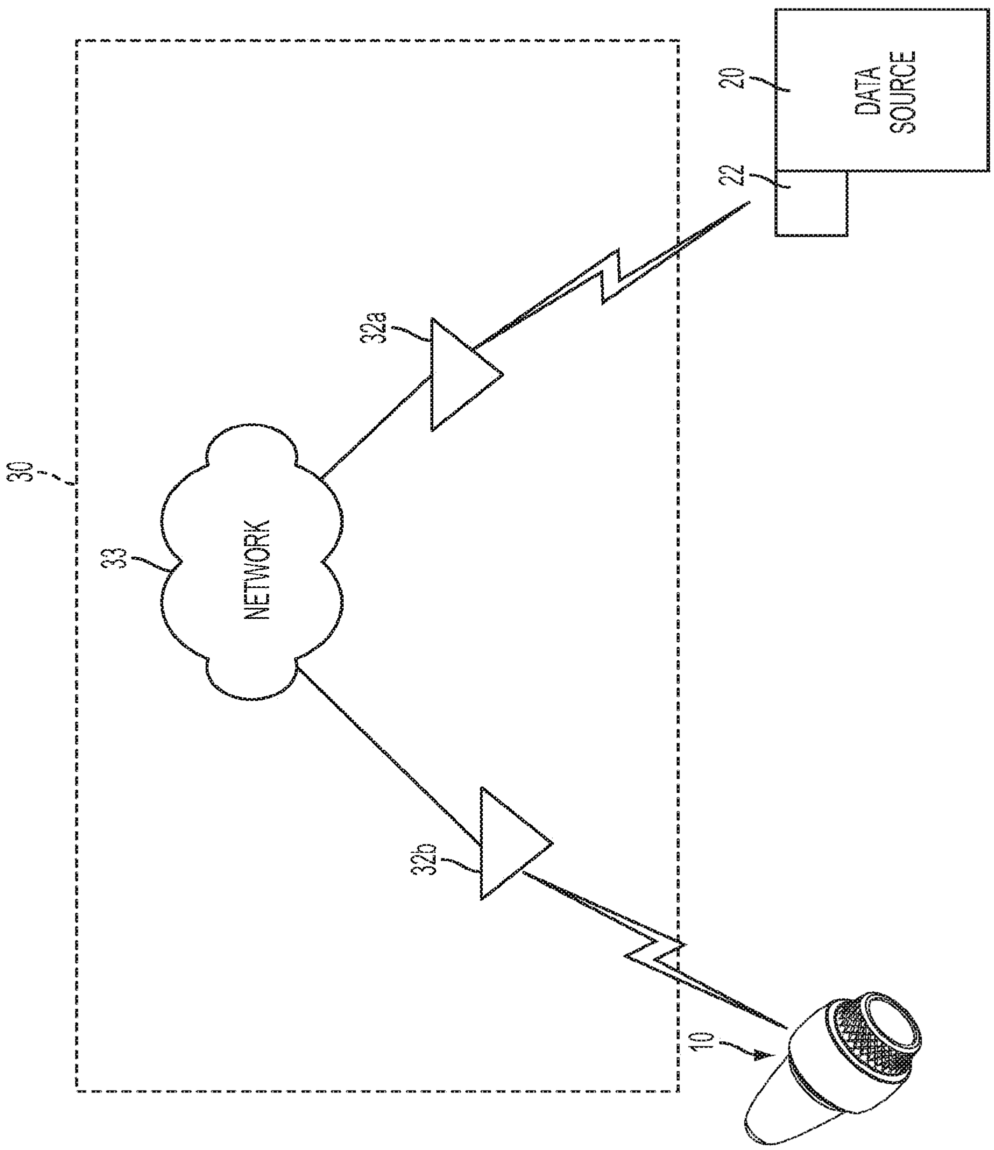

FIG. 2C

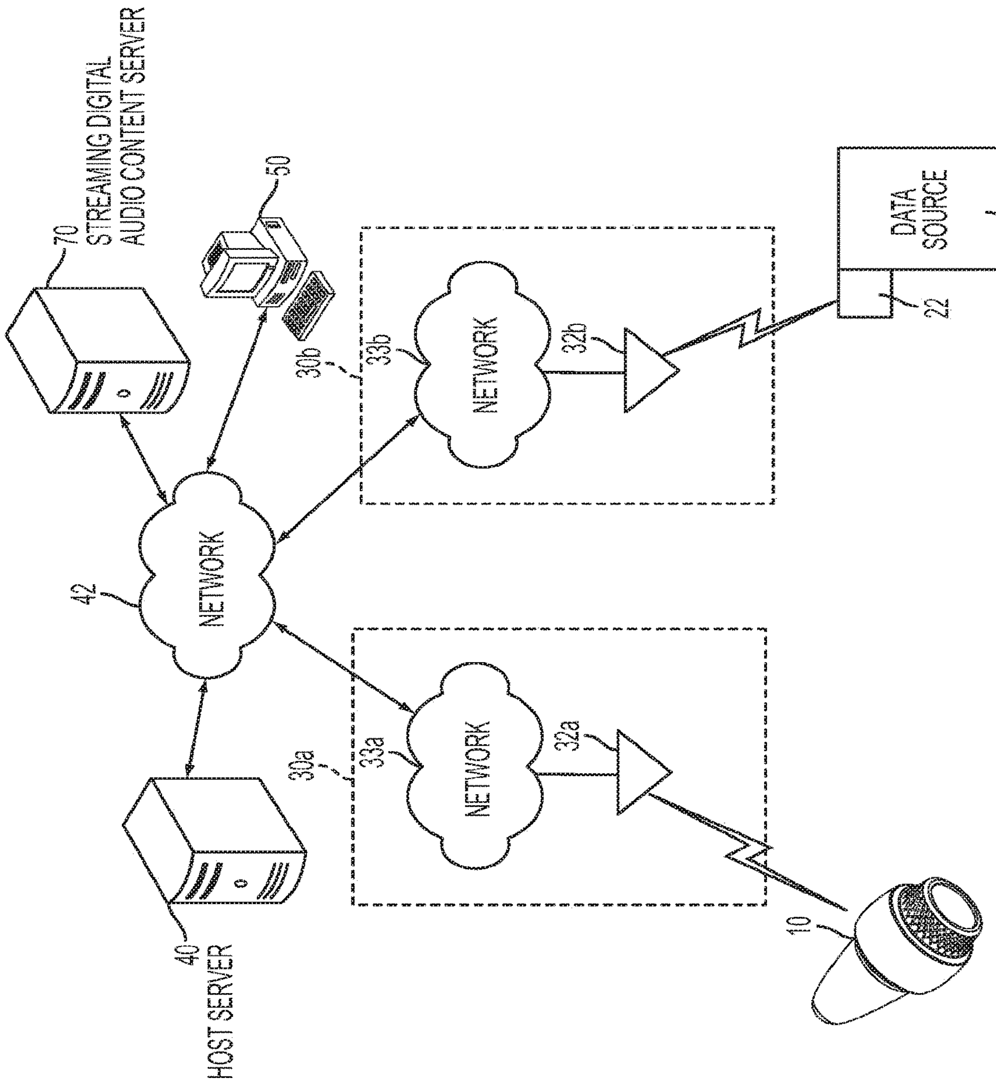
70
STREAMING DIGITAL
AUDIO CONTENT SERVER
50
42
NETWORK
30b
33b
NETWORK
32b
DATA
SOURCE
20
22
40
HOST SERVER
30a
33a
NETWORK
32a
10

FIG. 2D

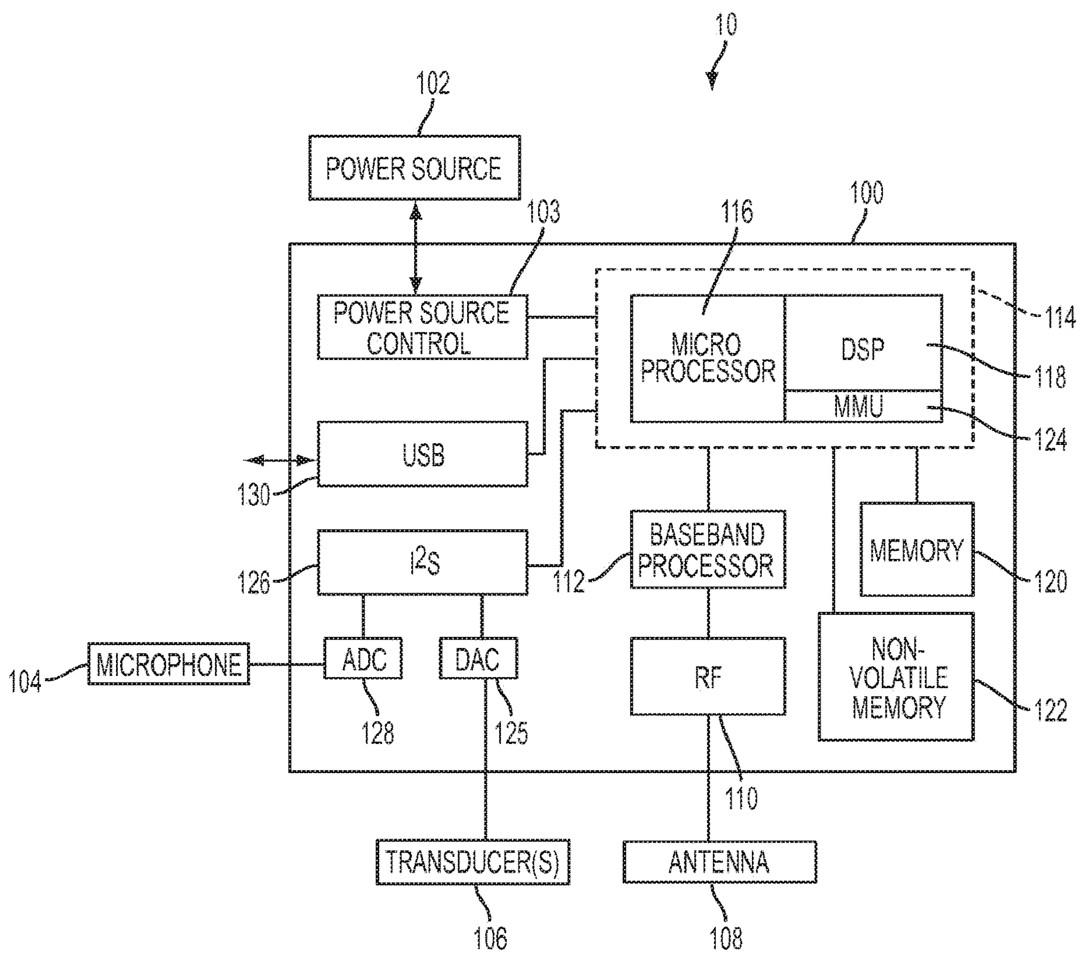
10
102
POWER SOURCE
103
116
100
POWER SOURCE CONTROL
MICRO PROCESSOR
DSP
114
118
MMU
124
USB
130
I2S
126
BASEBAND PROCESSOR
112
MEMORY
120
104
MICROPHONE
ADC
DAC
RF
NON-VOLATILE MEMORY
122
128
125
110
TRANSDUCER(S)
ANTENNA
106
108

FIG. 3

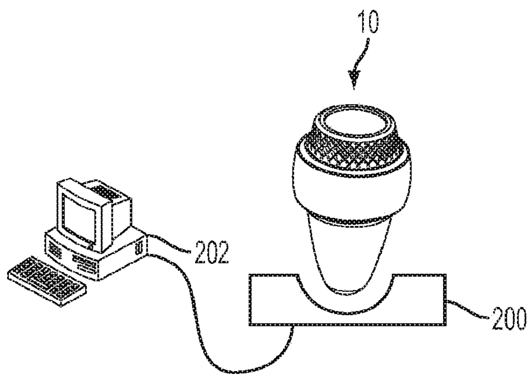

FIG. 4A

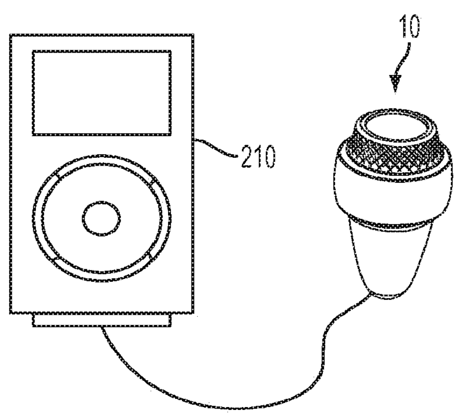

FIG. 4B

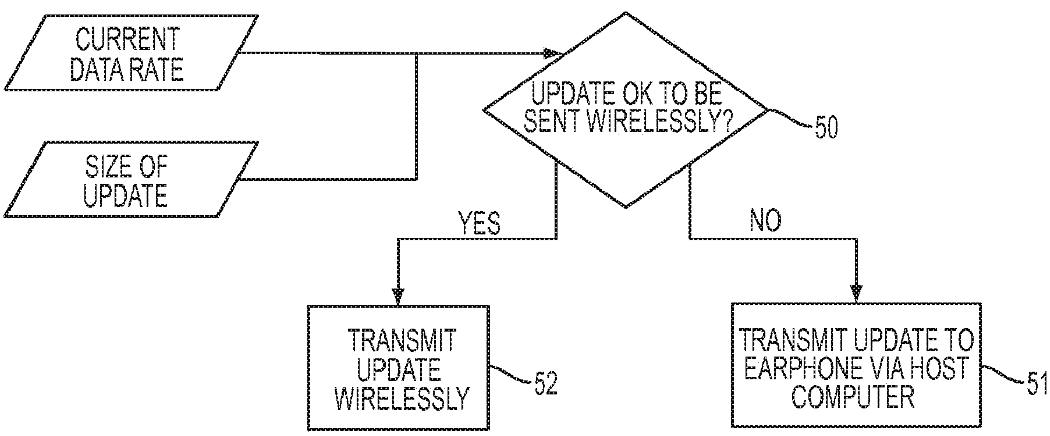
CURRENT DATA RATE
SIZE OF UPDATE
UPDATE OK TO BE SENT WIRELESSLY?
50
YES
NO
TRANSMIT UPDATE WIRELESSLY
52
TRANSMIT UPDATE TO EARPHONE VIA HOST COMPUTER
51

FIG. 5

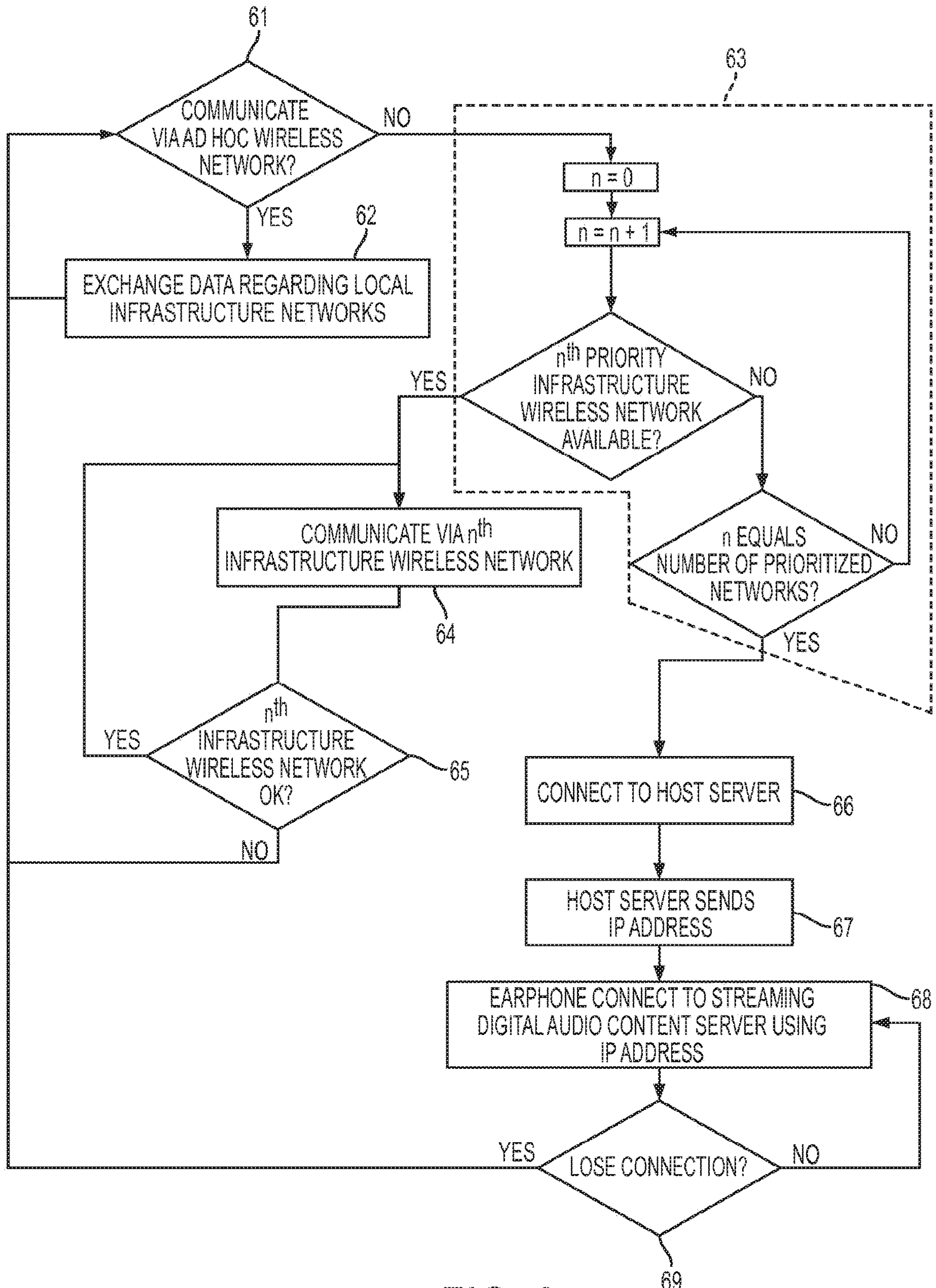
61
COMMUNICATE VIA AD HOC WIRELESS NETWORK?
NO
YES
62
EXCHANGE DATA REGARDING LOCAL INFRASTRUCTURE NETWORKS
63
n = 0
n = n + 1
nth PRIORITY INFRASTRUCTURE WIRELESS NETWORK AVAILABLE?
YES
NO
COMMUNICATE VIA nth INFRASTRUCTURE WIRELESS NETWORK
64
n EQUALS NUMBER OF PRIORITIZED NETWORKS?
NO
YES
nth INFRASTRUCTURE WIRELESS NETWORK OK?
YES
NO
65
CONNECT TO HOST SERVER
66
HOST SERVER SENDS IP ADDRESS
67
EARPHONE CONNECT TO STREAMING DIGITAL AUDIO CONTENT SERVER USING IP ADDRESS
68
LOSE CONNECTION?
YES
NO
69

FIG. 6

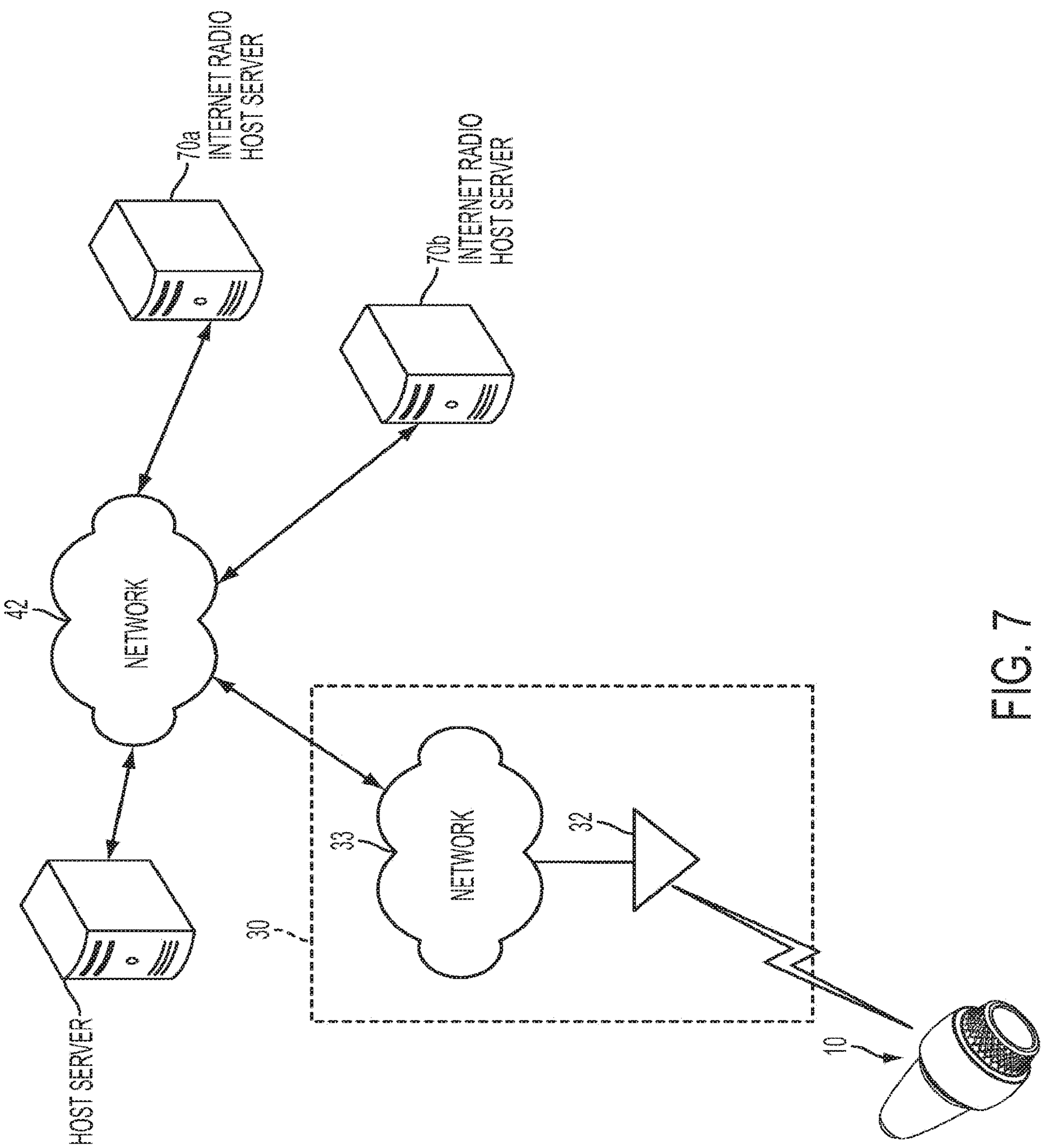
70a
INTERNET RADIO
HOST SERVER
70b
INTERNET RADIO
HOST SERVER
42
NETWORK
33
NETWORK
32
30
10
HOST SERVER

FIG. 7

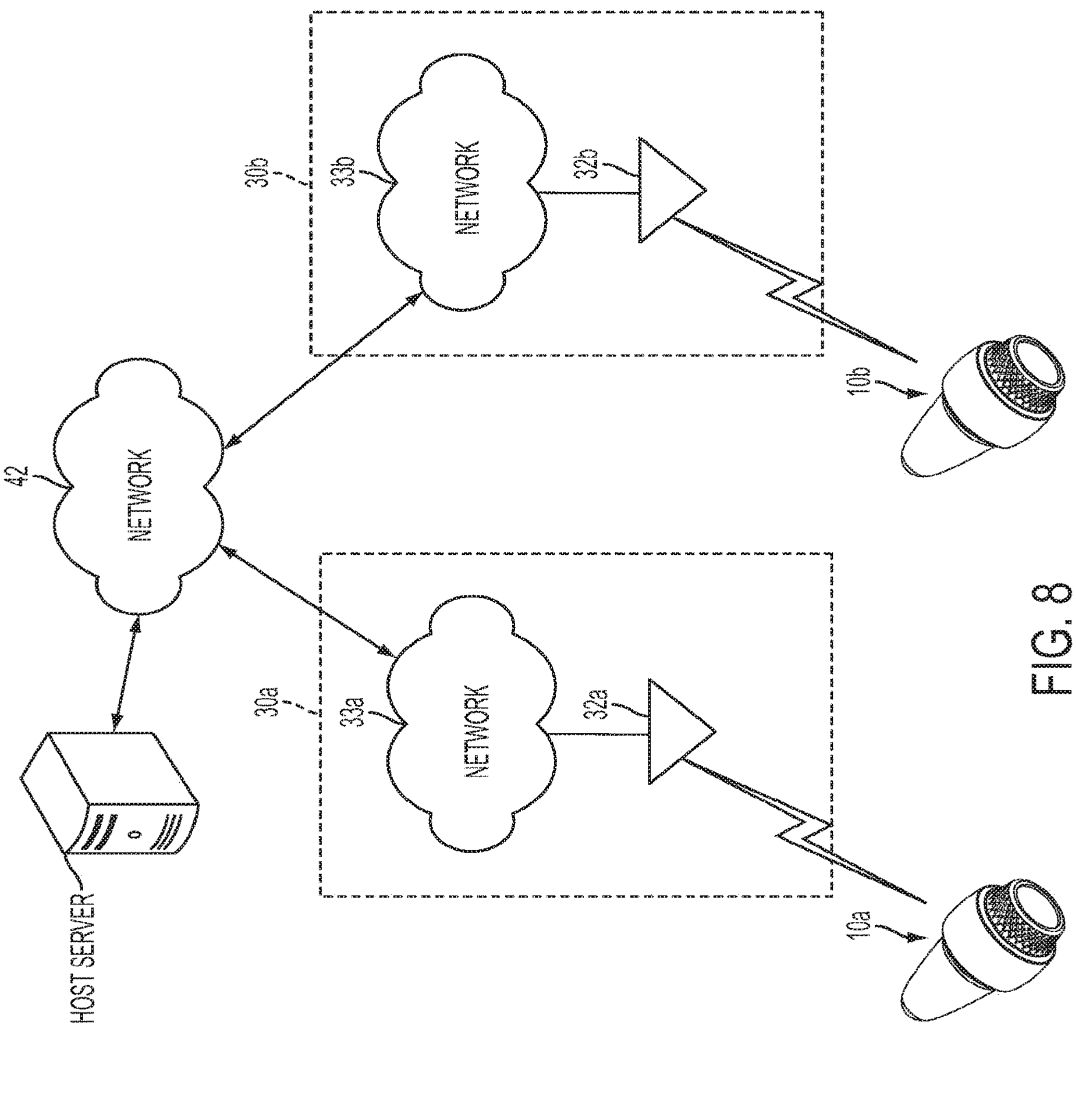
HOST SERVER
42
NETWORK
30a
33a
NETWORK
32a
10a
30b
33b
NETWORK
32b
10b

FIG. 8

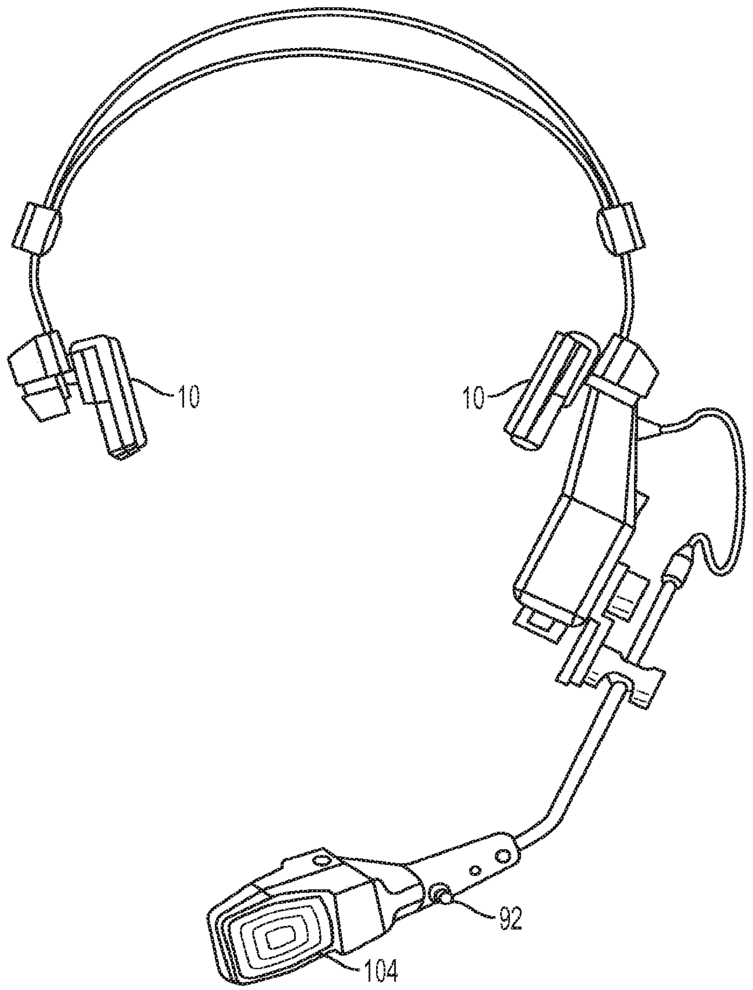

FIG. 9

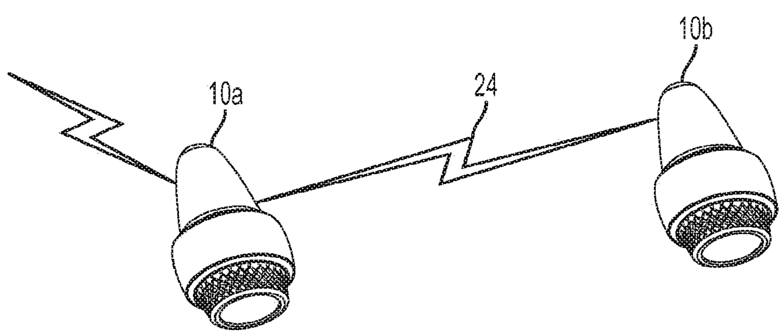

FIG. 10

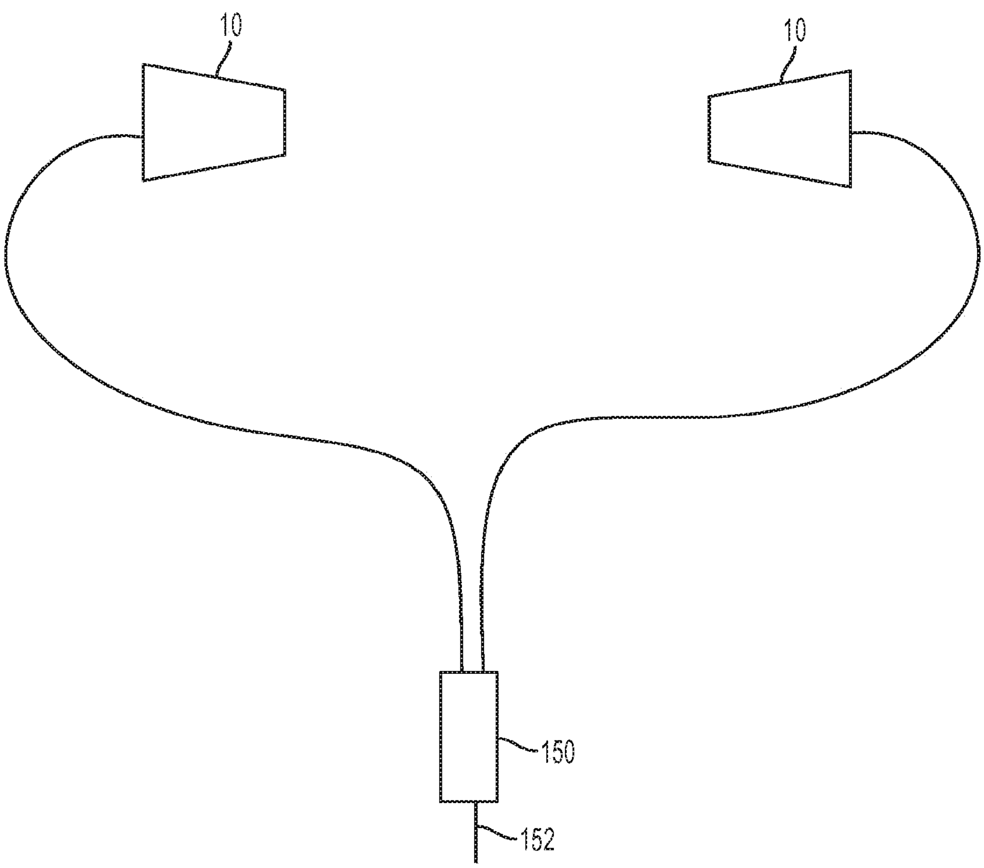

FIG. 11

SYSTEM WITH WIRELESS EARPHONES

PRIORITY CLAIM

The present application claims priority as a continuation to U.S. nonprovisional patent application Ser. No. 16/375,879, filed Apr. 5, 2019, which is a continuation of U.S. nonprovisional patent application Ser. No. 16/182,927, filed Nov. 7, 2018, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/962,305, filed Apr. 25, 2018, now U.S. Pat. No. 10,206,025, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/650,362, filed Jul. 14, 2017, now U.S. Pat. No. 9,986,325, issued May 29, 2018, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/293,785, filed Oct. 14, 2016, now U.S. Pat. No. 9,729,959, issued Aug. 8, 2017, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/082,040, filed Mar. 28, 2016, now U.S. Pat. No. 9,497,535, issued Nov. 15, 2016, which is a continuation of U.S. nonprovisional patent application Ser. No. 14/695,696, filed Apr. 24, 2015, now U.S. Pat. No. 9,438,987, issued on Sep. 6, 2016, which is a continuation of U.S. nonprovisional patent application Ser. No. 13/609,409, filed Sep. 11, 2012, now U.S. Pat. No. 9,049,502, issued Jun. 2, 2015, which is a continuation of U.S. nonprovisional patent application Ser. No. 13/459,291, filed Apr. 30, 2012, now U.S. Pat. No. 8,571,544, issued Oct. 29, 2013, which is a continuation of U.S. patent application Ser. No. 12/936,488, filed Dec. 20, 2010, now U.S. Pat. No. 8,190,203, issued May 29, 2012, which is a national stage entry of PCT/US2009/039754, filed Apr. 7, 2009, which claims priority to U.S. provisional patent application Ser. No. 61/123,265, filed Apr. 7, 2008, all of which are incorporated herein by reference in their entireties.

CROSS-REFERENCE TO RELATED APPLICATIONS

U.S. nonprovisional patent application Ser. No. 14/031,938, filed Sep. 13, 2013, now U.S. Pat. No. 8,655,420, issued Feb. 18, 2014, is also a continuation of U.S. nonprovisional patent application Ser. No. 13/609,409, filed Sep. 11, 2012, now U.S. Pat. No. 9,049,502, mentioned above.

BACKGROUND

Digital audio players, such as MP3 players and iPods, that store and play digital audio files, are very popular. Such devices typically comprise a data storage unit for storing and playing the digital audio, and a headphone set that connects to the data storage unit, usually with a ¼" or a 3.5 mm jack and associated cord. Often the headphones are in-ear type headphones. The cord, however, between the headphones and the data storage unit can be cumbersome and annoying to users, and the length of the cord limits the physical distance between the data storage unit and the headphones. Accordingly, some cordless headphones have been proposed, such as the Monster iFreePlay cordless headphones from Apple Inc., which include a docking port on one of the earphones that can connect directly to an iPod Shuffle. Because they have the docking port, however, the Monster iFreePlay cordless headphones from Apple are quite large and are not in-ear type phones. Recently, cordless headphones that connect wirelessly via IEEE 802.11 to a WLAN-ready laptop or personal computer (PC) have been proposed, but such headphones are also quite large and not in-ear type phones.

SUMMARY

In one general aspect, the present invention is directed to a wireless earphone that comprises a transceiver circuit for receiving streaming audio from a data source, such as a digital audio player or a computer, over an ad hoc wireless network. When the data source and the earphone are out of range via the ad hoc wireless network, they may transition automatically to a common infrastructure wireless network (e.g., a wireless LAN). If there is no common infrastructure wireless network for both the data source and the earphone, the earphone may connect via an available infrastructure wireless network to a host server. The host server may, for example, broadcast streaming audio to the earphone and/or transmit to the earphone a network address (e.g., an Internet Protocol (IP) address) for a network-connected content server that streams digital audio. The earphone may then connect to the content server using the IP address. The content server may be an Internet radio server, including, for example, an Internet radio server that broadcasts streaming audio from the data source or some other content.

These and other advantageous, unique aspects of the wireless earphone are described below.

FIGURES

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures, wherein:

FIGS. **1**A-**1**E are views of a wireless earphone according to various embodiments of the present invention;

FIGS. **2**A-**2**D illustrate various communication modes for a wireless earphone according to various embodiments of the present invention;

FIG. **3** is a block diagram of a wireless earphone according to various embodiments of the present invention;

FIGS. **4**A-**4**B show the wireless earphone connected to another device according to various embodiments of the present invention;

FIG. **5** is a diagram of a process implemented by a host server according to various embodiments of the present invention;

FIG. **6** is a diagram of a process implemented by the wireless earphone to transition automatically between wireless networks according to various embodiments of the present invention;

FIGS. **7**, **8** and **10** illustrate communication systems involving the wireless earphone according to various embodiments of the present invention;

FIG. **9** is a diagram of a headset including a wireless earphone and a microphone according to various embodiments of the present invention; and

FIG. **11** is a diagram of a pair of wireless earphones with a dongle according to various embodiments of the present invention.

DESCRIPTION

In one general aspect, the present invention is directed to a wireless earphone that receives streaming audio data via ad hoc wireless networks and infrastructure wireless networks, and that transitions seamlessly between wireless networks. The earphone may comprise one or more in-ear, on-ear, or over-ear speaker elements. Two exemplary in-ear earphone shapes for the wireless earphone **10** are shown in FIGS. **1**A and **1**B, respectively, although in other embodiments the earphone may take different shapes and the exemplary

shapes shown in FIGS. **1**A and **1**B are not intended to be limiting. In one embodiment, the earphone transitions automatically and seamlessly, without user intervention, between communication modes. That is, the earphone may transition automatically from an ad hoc wireless network to an infrastructure wireless network, without user intervention. As used herein, an "ad hoc wireless network" is a network where two (or more) wireless-capable devices, such as the earphone and a data source, communicate directly and wirelessly, without using an access point. An "infrastructure wireless network," on the other hand, is a wireless network that uses one or more access points to allow a wireless-capable device, such as the wireless earphone, to connect to a computer network, such as a LAN or WAN (including the Internet).

FIGS. **1**A and **1**B show example configurations for a wireless earphone **10** according to various embodiments of the present invention. The examples shown in FIGS. **1**A and **1**B are not limiting and other configurations are within the scope of the present invention. As shown in FIGS. **1**A and **1**B, the earphone **10** may comprise a body **12**. The body **12** may comprise an ear canal portion **14** that is inserted in the ear canal of the user of the earphone **10**. In various embodiments, the body **12** also may comprise an exterior portion **15** that is not inserted into user's ear canal. The exterior portion **15** may comprise a knob **16** or some other user control (such as a dial, a pressure-activated switch, lever, etc.) for adjusting the shape of the ear canal portion **14**. That is, in various embodiments, activation (e.g. rotation) of the knob **16** may cause the ear canal portion **14** to change shape so as to, for example, radially expand to fit snugly against all sides of the user's ear canal. Further details regarding such a shape-changing earbud earphone are described in application PCT/US08/88656, filed 31 Dec. 2008, entitled "Adjustable Shape Earphone," which is incorporated herein by reference in its entirety. The earphone **10** also may comprise a transceiver circuit housed within the body **12**. The transceiver circuit, described further below, may transmit and receive the wireless signals, including receive streaming audio for playing by the earphone **10**. The transceiver circuit may be housed in the exterior portion **15** of the earphone **10** and/or in the ear canal portion **14**.

Although the example earphones **10** shown in FIGS. **1**A and **1**B include a knob **16** for adjusting the shape of the ear canal portion **14**, the present invention is not so limited, and in other embodiments, different means besides a knob **16** may be used to adjust the ear canal portion **14**. In addition, in other embodiments, the earphone **10** may not comprise a shape-changing ear canal portion **14**.

In various embodiments, the user may wear two discrete wireless earphones **10**: one in each ear. In such embodiments, each earphone **10** may comprise a transceiver circuit. In such embodiments, the earphones **10** may be connected by a string or some other cord-type connector to keep the earphones **10** from being separated.

In other embodiments, as shown in FIG. **1**C, a headband **19** may connect the two (left and right) earphones **10**. The headband **19** may be an over-the-head band, as shown in the example of FIG. **1**C, or the headband may be a behind-the-head band. In embodiments comprising a headband **19**, each earphone **10** may comprise a transceiver circuit; hence, each earphone **10** may receive and transmit separately the wireless communication signals. In other embodiments comprising a headband **19**, only one earphone **10** may comprise the transceiver circuit, and a wire may run along the headband **19** to the other earphone **10** to connect thereby the transceiver circuit to the acoustic transducer in the earphone that

does not comprise the transceiver circuit. The embodiment shown in FIG. **1**C comprises on-ear earphones **10**; in other embodiments, in-ear or over-ear earphones may be used.

In other embodiments, the earphone **10** may comprise a hanger bar **17** that allows the earphone **10** to clip to, or hang on, the user's ear, as shown in the illustrated embodiment of FIGS. **1**D-**1**E. FIG. **1**D is a perspective view of the earphone and FIG. **1**E is a side view according to one embodiment. As shown in the illustrated embodiment, the earphone **10** may comprise dual speaker elements **106**-A, **106**-B. One of the speaker elements (the smaller one) **106**-A is sized to fit into the cavum concha of the listener's ear and the other element (the larger one) **106**-B is not. The listener may use the hanger bar to position the earphone on the listener's ear. In that connection, the hanger bar may comprise a horizontal section that rests upon the upper external curvature of the listener's ear behind the upper portion of the auricula (or pinna). The earphone may comprise a knurled knob that allows the user to adjust finely the distance between the horizontal section of the hanger bar and the speaker elements, thereby providing, in such embodiments, another measure of adjustability for the user. More details regarding such a dual element, adjustable earphone may be found in U.S. provisional patent application Ser. No. 61/054,238, which is incorporated herein by reference in its entirety.

FIGS. **2**A-**2**D illustrate various communication modes for a wireless data communication system involving the earphone **10** according to embodiments of the present invention. As shown in FIG. **2**A, the system comprises a data source **20** in communication with the earphone **10** via an ad hoc wireless network **24**. The earphone **10**, via its transceiver circuit (described in more detail below), may communicate wirelessly with a data source **20**, which may comprise a wireless network adapter **22** for transmitting the digital audio wirelessly. For example, the data source **20** may be a digital audio player (DAP), such as an mp3 player or an iPod, or any other suitable digital audio playing device, such as a laptop or personal computer, that stores and/or plays digital audio files. In other embodiments, the data source **20** may generate analog audio, and the wireless network adapter **22** may encode the analog audio into digital format for transmission to the earphone **10**.

The wireless network adapter **22** may be an integral part of the data source **20**, or it may be a separate device that is connected to the data source **20** to provide wireless connectivity for the data source **20**. For example, the wireless network adapter **22** may comprise a wireless network interface card (WNIC) or other suitable transceiver that plugs into a USB port or other port or jack of the data source **20** (such as a TRS connector) to stream data, e.g., digital audio files, via a wireless network (e.g., the ad hoc wireless network **24** or an infrastructure wireless network). The digital audio transmitted from the data source **20** to the earphone **10** via the wireless networks may comprise compressed or uncompressed audio. Any suitable file format may be used for the audio, including mp3, lossy or lossless WMA, Vorbis, Musepack, FLAC, WAV, AIFF, AU, or any other suitable file format.

When in range, the data source **20** may communicate with the earphone **10** via the ad hoc wireless network **24** using any suitable wireless communication protocol, including Wi-Fi (e.g., IEEE 802.11a/b/g/n), WiMAX (IEEE 802.16), Bluetooth, Zigbee, UWB, or any other suitable wireless communication protocol. For purposes of the description to follow, it is assumed that the data source **20** and the earphone **10** communicate using a Wi-Fi protocol, although the invention is not so limited and other wireless communication

protocols may be used in other embodiments of the invention. The data source **20** and the earphone **10** are considered in range for the ad hoc wireless network **24** when the signal strengths (e.g., the RSSI) of the signals received by the two devices are above a threshold minimum signal strength level. For example, the data source **20** and the earphone **10** are likely to be in range for an ad hoc wireless network when then are in close proximity, such as when the wearer of the earphone **10** has the data source **20** on his/her person, such as in a pocket, strapped to their waist or arm, or holding the data source in their hand.

When the earphone **10** and the data source **20** are out of range for the ad hoc wireless network **24**, that is, when the received signals degrade below the threshold minimum signal strength level, both the earphone **10** and the data source **20** may transition automatically to communicate over an infrastructure wireless network (such as a wireless LAN (WLAN)) **30** that is in the range of both the earphone **10** and the data source **20**, as shown in FIG. **2**B. The earphone **10** and the data source **20** (e.g., the wireless network adapter **22**) may include firmware, as described further below, that cause the components to make the transition to a common infrastructure wireless network **30** automatically and seamlessly, e.g., without user intervention. The earphone **10** may cache the received audio in a buffer or memory for a time period before playing the audio. The cached audio may be played after the connection over the ad hoc wireless network is lost to give the earphone **10** and the data source **20** time to connect via the infrastructure wireless network.

For example, as shown in FIG. **2**B, the infrastructure network may comprise an access point **32** that is in the range of both the data source **20** and the earphone **10**. The access point **32** may be an electronic hardware device that acts as a wireless access point for, and that is connected to, a wired and/or wireless data communication network **33**, such as a LAN or WAN, for example. The data source **20** and the earphone **10** may both communicate wirelessly with the access point **32** using the appropriate network data protocol (a Wi-Fi protocol, for example). The data source **20** and the earphone **10** may both transition automatically to an agreed-upon WLAN **30** that is in the range of both devices when they cannot communicate satisfactorily via the ad hoc wireless network **24**. A procedure for specifying an agreed-upon infrastructure wireless network **30** is described further below. Alternatively, the infrastructure wireless network **30** may have multiple access points **32*a-b***, as shown in FIG. **2**C. In such an embodiment, the data source **20** may communicate wirelessly with one access point **32*b*** and the earphone **10** may communicate wirelessly with another access point **32*a*** of the same infrastructure wireless network **30**. Again, the data source **20** and the earphone **10** may transition to an agreed-upon WLAN.

If there is no suitable common infrastructure wireless network over which the earphone **10** and the data source **20** can communicate, as shown in FIG. **2**D, the earphone **10** may transition to communicate with an access point **32*a*** for an available (first) wireless network (e.g., WLAN) **30*a*** that is in the range of the earphone **10**. In this mode, the earphone **10** may connect via the wireless network **30*a*** to a network-enabled host server **40**. The host server **40** may be connected to the wireless network **30*a*** via an electronic data communication network **42**, such as the Internet. In one mode, the host server **40** may transmit streaming digital audio via the networks **33*a***, **42** to the earphone **10**. In another mode, the host server **40** may transmit to the earphone **10** a network address, such as an Internet Protocol (IP) address, for a streaming digital audio content server **70** on the network **42**. Using the received IP address, the earphone **10** may connect to the streaming digital audio content server **70** via the networks **30*a***, **42** to receive and process digital audio from the streaming digital audio content server **70**.

The digital audio content server **70** may be, for example, an Internet radio station server. The digital audio content server **70** may stream digital audio over the network **42** (e.g., the Internet), which the earphone **10** may receive and process. In one embodiment, the streaming digital audio content server **70** may stream digital audio received by the streaming digital audio content server **70** from the data source **20**. For example, where the data source **20** is a wireless-capable device, such as a portable DAP, the data source **20** may connect to the streaming digital audio content server **70** via a wireless network **30*b*** and the network **42**. Alternatively, where for example the data source **20** is non-wireless-capable device, such as a PC, the data source **20** may have a direct wired connection to the network **42**. After being authenticated by the streaming digital audio content server **70**, the data source **20** may stream digital audio to the streaming digital audio content server **70**, which may broadcast the received digital audio over the network **42** (e.g., the Internet). In such a manner, the user of the earphone **10** may listen to audio from the data source **20** even when (i) the earphone **10** and the data source **20** are not in communication via an ad hoc wireless network **24** and (ii) the earphone **10** and the data source **20** are not in communication via a common local infrastructure wireless network **30**.

FIG. **3** is a block diagram of the earphone **10** according to various embodiments of the present invention. In the illustrated embodiment, the earphone **10** comprises a transceiver circuit **100** and related peripheral components. As shown in FIG. **3**, the peripheral components of the earphone **10** may comprise a power source **102**, a microphone **104**, one or more acoustic transducers **106** (e.g., speakers), and an antenna **108**. The transceiver circuit **100** and some of the peripheral components (such as the power source **102** and the acoustic transducers **106**) may be housed within the body **12** of the earphone **10** (see FIG. **1**). Other peripheral components, such as the microphone **104** and the antenna **108** may be external to the body **12** of the earphone **10**. In addition, some of the peripheral components, such as the microphone **104**, are optional in various embodiments.

In various embodiments, the transceiver circuit **100** may be implemented as a single integrated circuit (IC), such as a system-on-chip (SoC), which is conducive to miniaturizing the components of the earphone **10**, which is advantageous if the earphone **10** is to be relatively small in size, such as an in-ear earphone (see FIGS. **1**A-**1**B for example). In alternative embodiments, however, the components of the transceiver circuit **100** could be realized with two or more discrete ICs or other components, such as separate ICs for the processors, memory, and RF (e.g., Wi-Fi) module, for example.

The power source **102** may comprise, for example, a rechargeable or non-rechargeable battery (or batteries). In other embodiments, the power source **102** may comprise one or more ultracapacitors (sometimes referred to as supercapacitors) that are charged by a primary power source. In embodiments where the power source **102** comprises a rechargeable battery cell or an ultracapacitor, the battery cell or ultracapacitor, as the case may be, may be charged for use, for example, when the earphone **10** is connected to a docking station or computer. The docking station may be connected to or part of a computer device, such as a laptop computer or PC. In addition to charging the rechargeable

power source **102**, the docking station and/or computer may facilitate downloading of data to and/or from the earphone **10**. In other embodiments, the power source **102** may comprise capacitors passively charged with RF radiation, such as described in U.S. Pat. No. 7,027,311. The power source **102** may be coupled to a power source control module **103** of transceiver circuit **100** that controls and monitors the power source **102**.

The acoustic transducer(s) **106** may be the speaker element(s) for conveying the sound to the user of the earphone **10**. According to various embodiments, the earphone **10** may comprise one or more acoustic transducers **106**. For embodiments having more than one transducer, one transducer may be larger than the other transducer, and a crossover circuit (not shown) may transmit the higher frequencies to the smaller transducer and may transmit the lower frequencies to the larger transducer. More details regarding dual element earphones are provided in U.S. Pat. No. 5,333,206, assigned to Koss Corporation, which is incorporated herein by reference in its entirety.

The antenna **108** may receive and transmit the wireless signals from and to the wireless networks **24**, **30**. A RF (e.g., Wi-Fi) module **110** of the transceiver circuit **100** in communication with the antenna **108** may, among other things, modulate and demodulate the signals transmitted from and received by the antenna **108**. The RF module **110** communicates with a baseband processor **112**, which performs other functions necessary for the earphone **10** to communicate using the Wi-Fi (or other communication) protocol.

The baseband processor **112** may be in communication with a processor unit **114**, which may comprise a microprocessor **116** and a digital signal processor (DSP) **118**. The microprocessor **116** may control the various components of the transceiver circuit **100**. The DSP **114** may, for example, perform various sound quality enhancements to the digital audio received by the baseband processor **112**, including noise cancellation and sound equalization. The processor unit **114** may be in communication with a volatile memory unit **120** and a non-volatile memory unit **122**. A memory management unit **124** may control the processor unit's access to the memory units **120**, **122**. The volatile memory **122** may comprise, for example, a random access memory (RAM) circuit. The non-volatile memory unit **122** may comprise a read only memory (ROM) and/or flash memory circuits. The memory units **120**, **122** may store firmware that is executed by the processor unit **114**. Execution of the firmware by the processor unit **114** may provide various functionality for the earphone **10**, such as the automatic transition between wireless networks as described herein. The memory units **120**, **122** may also cache received digital audio.

A digital-to-analog converter (DAC) **125** may convert the digital audio from the processor unit **114** to analog form for coupling to the acoustic transducer(s) **106**. An I^2S interface **126** or other suitable serial or parallel bus interface may provide the interface between the processor unit **114** and the DAC **125**. An analog-to-digital converter (ADC) **128**, which also communicates with the I^2S interface **126**, may convert analog audio signals picked up by the microphone **104** for processing by the processor unit **114**.

The transceiver circuit **100** also may comprise a USB or other suitable interface **130** that allows the earphone **10** to be connected to an external device via a USB cable or other suitable link. As shown in FIG. **4**A, the external device may be a docking station **200** connected to a computer device **202**. Also, in various embodiments, the earphone **10** could be connected directly to the computer **202** without the docking station **200**. In addition, the external device may be a DAP **210**, as shown in FIG. **4**B. In that way, the earphone **10** could connect directly to a data source **20**, such as the DAP **210** or the computer **202**, through the USB port **130**. In addition, through the USB port **130**, the earphone **10** may connect to a PC **202** or docking station **202** to charge up the power source **102** and/or to get downloads (e.g., data or firmware).

According to various embodiments, the earphone **10** may have an associated web page that a user may access through the host server **40** (see FIG. **2**D) or some other server. An authenticated user could log onto the website from a client computing device **50** (e.g., laptop, PC, handheld computer device, etc., including the data source **20**) (see FIG. **2**D) to access the web page for the earphone **10** to set various profile values for the earphone **10**. For example, at the web site, the user could set various content features and filters, as well as adjust various sound control features, such as treble, bass, frequency settings, noise cancellation settings, etc. In addition, the user could set preferred streaming audio stations, such as preferred Internet radio stations or other streaming audio broadcasts. That way, instead of listening to streaming audio from the data source **20**, the user could listen to Internet radio stations or other streaming audio broadcasts received by the earphone **10**. In such an operating mode, the earphone user, via the web site, may prioritize a number of Internet radio stations or other broadcast sources (hosted by streaming digital audio content servers **70**). With reference to FIG. **7**, the host server **40** may send the IP address for the earphone user's desired (e.g., highest priority) Internet radio station to the earphone **10**. A button **11** on the earphone **10**, such as on the rotating dial **16** as shown in the examples of FIGS. **1**A and **1**B, may allow the user to cycle through the preset preferred Internet radio stations. That is, for example, when the user presses the button **11**, an electronic communication may be transmitted to the host server **40** via the wireless network **30**, and in response to receiving the communication, the host server **40** may send the IP address for the user's next highest rated Internet radio station via the network **42** to the earphone **10**. The earphone **10** may then connect to the streaming digital audio content server **70** for that Internet radio station using the IP address provided by the host server **40**. This process may be repeated, e.g., cycled through, for each preset Internet radio station configured by the user of the earphone **10**.

At the web site for the earphone **10** hosted on the host server **40**, in addition to establishing the identification of digital audio sources (e.g., IDs for the user's DAP or PC) and earphones, the user could set parental or other user controls. For example, the user could restrict certain Internet radio broadcasts based on content or parental ratings, etc. That is, for example, the user could configure a setting through the web site that prevents the host server **40** from sending an IP address for a streaming digital audio content server **70** that broadcasts explicit content based on a rating for the content. In addition, if a number of different earphones **10** are registered to the same user, the user could define separate controls for the different earphones **10** (as well as customize any other preferences or settings particular to the earphones **10**, including Internet radio stations, sound quality settings, etc. that would later be downloaded to the earphones **10**). In addition, in modes where the host server **40** streams audio to the earphone **10**, the host server **40** may log the files or content streamed to the various earphones **10**, and the user could view at the web site the

files or content that were played by the earphones **10**. In that way, the user could monitor the files played by the earphones **10**.

In addition, the host server **40** may provide a so-called eavesdropping function according to various embodiments. The eavesdropping service could be activated via the web site. When the service is activated, the host server **40** may transmit the content that it is delivering to a first earphone **10***a* to another, second earphone **10***b*, as shown in FIG. **8**. Alternatively, the host server **40** may transmit to the second earphone **10***b* the most recent IP address for a streaming digital audio content server **70** that was sent to the first earphone **10***a*. The second earphone **10***b* may then connect to the streaming digital audio content server **70** that the first earphone **10***a* is currently connected. That way, the user of the second earphone **10***b*, which may be a parent, for example, may directly monitor the content being received by the first earphone **10***a*, which may belong to a child of the parent.

This function also could be present in the earphones **10** themselves, allowing a parent (or other user) to join an ad-hoc wireless network and listen to what their child (or other listener) is hearing. For example, with reference to FIG. **10**, a first earphone **10***a* may receive wireless audio, such as from the data source **20** or some other source, such as the host server **40**. The first earphone **10***a* may be programmed with firmware to broadcast the received audio to a second earphone **10***b* via an ad hoc wireless network **24**. That way, the wearer of the second earphone **10***b* can monitor in real-time the content being played by the first earphone **10***a*.

At the web site, the user may also specify the identification number ("ID") of their earphone(s) **10**, and the host server **40** may translate the ID to the current internet protocol (IP) addresses for the earphone **10** and for the data source **20**. This allows the user to find his or her data source **20** even when it is behind a firewall or on a changing IP address. That way, the host server **40** can match the audio from the data source **20** to the appropriate earphone **10** based on the specified device ID. The user also could specify a number of different data sources **20**. For example, the user's DAP may have one specified IP address and the user's home (or work) computer may have another specified IP address. Via the web site hosted by the host server **40**, the user could specify or prioritize from which source (e.g., the user's DAP or computer) the earphone **10** is to receive content.

The host server **40** (or some other server) may also push firmware upgrades and/or data updates to the earphone **10** using the IP addresses of the earphone **10** via the networks **30**, **42**. In addition, a user could download the firmware upgrades and/or data updates from the host server **40** to the client computing device **202** (see FIG. **4**A) via the Internet, and then download the firmware upgrades and/or data updates to the earphone **10** when the earphone **10** is connected to the client computer device **202** (such as through a USB port and/or the docking station **200**).

Whether the downloads are transmitted wirelessly to the earphone **10** or via the client computing device **202** may depend on the current data rate of the earphone **10** and the quantity of data to be transmitted to the earphone **10**. For example, according to various embodiments, as shown in the process flow of FIG. **5**, the host server **40** may be programmed, at step **50**, to make a determination, based on the current data rate for the earphone **10** and the size of the update, whether the update should be pushed to the earphone **10** wirelessly (e.g., via the WLAN **30***a* in FIG. **2**D). If the update is too large and/or the current data rate is too low that the performance of the earphone **10** will be adversely affected, the host server **40** may refrain from pushing the update to the earphone **10** wirelessly and wait instead to download the update to the client computing device **202** at step **51**. Conversely, if the host server **40** determines that, given the size of the update and the current data rate for the earphone **10** that the performance of the earphone **10** will not be adversely affected, the host server **40** may transmit the update wirelessly to the earphone **10** at step **52**.

As mentioned above, the processor unit **114** of the speakerphones **14** may be programmed, via firmware stored in the memory **120**, **122**, to have the ability to transition automatically from the ad hoc wireless network **24** to an infrastructure wireless network **30** (such as a WLAN) when the quality of the signal on the ad hoc wireless network **24** degrades below a suitable threshold (such as when the data source **20** is out of range for an ad hoc wireless network). In that case, the earphone **10** and the data source **20** may connect to a common infrastructure wireless network (e.g., WLAN) (see, for example, FIGS. **2**B-**2**C). Through the web site for the earphone **10**, described above, the user could specify a priority of infrastructure wireless networks **30** for the data source **20** and the earphone **10** to connect to when the ad hoc wireless network **24** is not available. For example, the user could specify a WLAN servicing his/her residence first, a WLAN servicing his/her place of employment second, etc. During the time that the earphone **10** and the data source **20** are connected via the ad hoc wireless network **24**, the earphone **10** and the data source **20** may exchange data regarding which infrastructure networks are in range. When the earphone **10** and the data source **20** are no longer in range for the ad hoc wireless network **24** (that is, for example, the signals between the device degrade below an acceptable level), they may both transition automatically to the highest prioritized infrastructure wireless network whose signal strength is above a certain threshold level. That way, even though the earphone **10** and the data source **20** are out of range for the ad hoc wireless network **24**, the earphone **10** may still receive the streaming audio from the data source **20** via the infrastructure wireless network **30** (see FIGS. **2**B-**2**C).

When none of the preferred infrastructure networks is in range, the earphone **10** may connect automatically to the host server **40** via an available infrastructure wireless network **30** (see FIG. **2**D), e.g., the infrastructure wireless network **30** having the highest RSSI and to which the earphone **10** is authenticated to use. The host server **40**, as mentioned above, may transmit IP addresses to the earphone **10** for streaming digital audio content servers **70** or the host sever **40** may stream digital audio to the earphone **10** itself when in this communication mode.

FIG. **6** is a diagram of the process flow, according to one embodiment, implemented by the transceiver circuit **100** of the earphone **10**. The process shown in FIG. **6** may be implemented in part by the processor unit **114** executing firmware stored in a memory unit **120**, **122** of the transceiver circuit **100**. At step **61**, the earphone **10** may determine if it can communicate with the data source **20** via an ad hoc wireless network **24**. That is, the earphone **10** may determine if the strength of the wireless signals from the data source **20** exceed some minimum threshold. If so, the data source **20** and the earphone **10** may communicate wirelessly via the ad hoc wireless network **24** (see FIG. **2**A). While in this communication mode, at step **62**, the data source **20** and the earphone **10** also may exchange data regarding the local infrastructure wireless networks, if any, in the range of the data source **20** and the earphone **10**, respectively. For

example, the earphone **10** may transmit the ID of local infrastructure wireless networks **30** that the earphone **10** can detect whose signal strength (e.g., RSSI) exceeds some minimum threshold level. Similarly, the data source **20** may transmit the ID the local infrastructure wireless networks **30** that the data source **20** can detect whose signal strength (e.g., RSSI) exceeds some minimum threshold level. The earphone **10** may save this data in a memory unit **120**, **122**. Similarly, the data source **20** may store in memory the wireless networks that the earphone **10** is detected.

The data source **20** and the earphone **10** may continue to communicate via the ad hoc wireless network mode **24** until they are out of range (e.g., the signal strengths degrade below a minimum threshold level). If an ad hoc wireless network **24** is not available at block **61**, the transceiver circuit **100** and the data source **20** may execute a process, shown at block **63**, to connect to the user's highest prioritized infrastructure wireless network **30**. For example, of the infrastructure wireless networks whose signal strength exceeded the minimum threshold for both the earphone **10** and the data source **20** determined at step **62**, the earphone **10** and the data source **20** may both transition to the infrastructure wireless network **30** having the highest priority, as previously set by the user (seen FIGS. **2**B-**2**C, for example). For example, if the user's highest prioritized infrastructure wireless network **30** is not available, but the user's second highest prioritized infrastructure wireless network **30** is, the earphone **10** and the data source **20** may both transition automatically to the user's second highest prioritized infrastructure wireless network **30** at block **64**. As shown by the loop with block **65**, the earphone **10** and the data source **20** may continue to communicate via one of the user's prioritized infrastructure wireless networks **30** as long as the infrastructure wireless network **30** is available. If the infrastructure wireless network becomes unavailable, the process may return to block **61**.

If, however, no ad hoc wireless network and none of the user's prioritized infrastructure wireless networks are available, the earphone **10** may transition automatically to connect to the host server **40** at block **66** (see FIG. **2**D) using an available infrastructure wireless network **30**. At block **67**, the host server **40** may transmit an IP address to the earphone **10** for one of the streaming digital audio content servers **70**, and at block **68** the earphone **10** may connect to the streaming digital audio content server **70** using the received IP address. At step **69**, as long as the earphone **10** is connected to the streaming digital audio content server **70**, the earphone **10** may continue to communicate in this mode. However, if the earphone **10** loses its connection to the digital audio content server **70**, the process may return to block **61** in one embodiment. As mentioned above, at block **67**, instead of sending an IP address for a streaming digital audio content server **70**, the host server **40** may stream digital audio to the earphone **10**. The user, when configuring their earphone **10** preferences via the web site, may specify and/or prioritize whether the host server **40** is to send IP addresses for the streaming digital audio content servers **70** and/or whether the host server **40** is to stream audio to the earphone **10** itself.

In another embodiment, the earphone **10** may be programmed to transition automatically to the host server **40** when the earphone **10** and the data source **20** are not in communication via the ad hoc wireless network **24**. That is, in such an embodiment, the earphone **10** may not try to connect via a local infrastructure wireless network **30** with the data source **20**, but instead transition automatically to connect to the host server **40** (see FIG. **2**D).

In various embodiments, as shown in FIG. **1**B, the button **11** or other user selection device that allows the wearer of the earphone **10** to indicate approval and/or disapproval of songs or other audio files listened to by the wearer over an Internet radio station. The approval/disapproval rating, along with metadata for the song received by the earphone **10** with the streaming audio, may be transmitted from the transceiver circuit **100** of the earphone **10** back to the host server **40**, which may log the songs played as well as the ratings for the various songs/audio files. In addition to being able to view the logs at the website, the host server **40** (or some other server) may send an email or other electronic communication to the earphone user, at a user specified email address or other address, which the user might access from their client communication device **50** (see FIG. **2**D). The email or other electronic communication may contain a listing of the song/audio files for which the user gave approval ratings using the button **11** or other user selection device. Further, the email or other electronic communication may provide a URL link for a URL at which the user could download song/audio files that the user rated (presumably song/audio files for which the user gave an approval rating). In some instances, the user may be required to pay a fee to download the song/audio file.

The user song ratings also may be used by the host server **40** to determine the user's musical preferences and offer new music that the user might enjoy. More details about generating user play lists based on song ratings may be found in published U.S. patent applications Pub. No. 2006/0212444, Pub. No. 2006/0206487, and Pub. No. 2006/0212442, and U.S. Pat. No. 7,003,515, which are incorporated herein by reference in their entirety.

In addition or alternatively, the user could log onto a web site hosted by the host server **40** (or some other server) to view the approval/disapproval ratings that the user made via the button **11** on the earphone **10**. The web site may provide the user with the option of downloading the rated songs/audio files (for the host server **40** or some other server system) to their client computer device **50**. The user could then have their earphone **10** connect to their client computer device **50** as a data source **20** via an ad hoc wireless network **24** (see FIG. **2**A) or via an infrastructure wireless network (see FIGS. **2**B-**2**D) to listen to the downloaded songs. In addition, the user could download the song files from their client computer device **50** to their DAP and listen to the downloaded song files from their DAP by using their DAP as the data source **20** in a similar manner.

Another application of the headsets may be in vehicles equipped with Wi-Fi or other wireless network connectivity. Published PCT application WO 2007/136620, which is incorporated herein by reference, discloses a wireless router for providing a Wi-Fi or other local wireless network for a vehicle, such as a car, truck, boat, bus, etc. In a vehicle having a Wi-Fi or other local wireless network, the audio for other media systems in the vehicle could be broadcast over the vehicle's wireless network. For example, if the vehicle comprises a DVD player, the audio from the DVD system could be transmitted to the router and broadcast over the vehicle's network. Similarly, the audio from terrestrial radio stations, a CD player, or an audio cassette player could be broadcast over the vehicle's local wireless network. The vehicle's passengers, equipped with the earphones **10**, could cycle through the various audio broadcasts (including the broadcasts from the vehicle's media system as well as broadcasts from the host server **40**, for example) using a selection button **11** on the earphone **10**. The vehicle may also be equipped with a console or terminal, etc., through which

a passenger could mute all of the broadcasts for direct voice communications, for example.

As described above, the earphones **10** may also include a microphone **104**, as shown in the example of FIG. **9**. The headset **90** shown in FIG. **9** includes two earphones **10**, both of which may include a transceiver circuit **100** or only one of which may include the transceiver circuit, as discussed above. The microphone **104** could be used to broadcast communications from one earphone wearer to another earphone wearer. For example, one wearer could activate the microphone by pressing a button **92** on the headset **90**. The headset **90** may then transmit a communication via an ad hoc wireless network **24** or other wireless network to a nearby recipient (or recipients) equipped with a headset **90** with a transceiver circuit **100** in one or both of the earphones **10**. When such communication is detected by the recipient's headset **90**, the streaming audio received over the wireless network by the recipient's headset **90** may be muted, and the intercom channel may be routed to the transducer(s) of the recipient's headset **90** for playing for the recipient. This functionality may be valuable and useful where multiple wearers of the headsets **90** are in close proximity, such as on motorcycles, for example.

Another exemplary use of the earphones **10** is in a factory, warehouse, construction site, or other environment that might be noisy. Persons (e.g., workers) in the environment could use the earphones **10** for protection from the surrounding noise of the environment. From a console or terminal, a person (e.g., a supervisor) could select a particular recipient for a communication over the Wi-Fi network (or other local wireless network). The console or terminal may have buttons, dials, or switches, etc., for each user/recipient, or it could have one button or dial through which the sender could cycle through the possible recipients. In addition, the console or terminal could have a graphical user interface, through which the sender may select the desired recipient(s).

As mentioned above, the earphones **10** may comprise a USB port. In one embodiment, as shown in FIG. **11**, the user may use an adapter **150** that connects to the USB port of each earphone **10**. The adapter **150** may also have a plug connector **152**, such as a 3.5 mm jack, which allows the user to connect the adapter **150** to devices having a corresponding port for the connector **152**. When the earphones **10** detect a connection via their USB interfaces in such a manner, the Wi-Fi (or other wireless protocol) components may shut down or go into sleep mode, and the earphones **10** will route standard headphone level analog signals to the transducer(s) **106**. This may be convenient in environments where wireless communications are not permitted, such as airplanes, but where there is a convenient source of audio contact. For example, the adapter **150** could plug into a person's DAP. The DSP **118** of the earphone **10** may still be operational in such a non-wireless mode to provide noise cancellation and any applicable equalization.

The examples presented herein are intended to illustrate potential and specific implementations of the embodiments. It can be appreciated that the examples are intended primarily for purposes of illustration for those skilled in the art. No particular aspect of the examples is/are intended to limit the scope of the described embodiments.

According to various embodiments, therefore, the present invention is directed to an earphone **10** that comprises a body **12**, where the body **12** comprises: (i) at least one acoustic transducer **106** for converting an electrical signal to sound; (ii) an antenna **108**; and (iii) a transceiver circuit **100** in communication with the at least one acoustic transducer **106** and the antenna **108**. The transceiver circuit **100** is for receiving and transmitting wireless signals via the antenna **108**, and the transceiver circuit **100** is for outputting the electrical signal to the at least one acoustic transducer **106**. The wireless transceiver circuit also comprises firmware, which when executed by the transceiver circuit, causes the transceiver circuit to: (i) receive digital audio wirelessly from a data source **20** via an ad hoc wireless network **24** when the data source **20** is in wireless communication range with the earphone **10** via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**, transition automatically to receive digital audio via an infrastructure wireless network **30**.

According to various implementations, the data source may comprise a portable digital audio player, such as an MP3 player, iPod, or laptop computer, or a nonportable digital audio player, such as a personal computer. In addition, the transceiver circuit **100** may comprise: (i) a wireless communication module **110** (such as a Wi-Fi or other wireless communication protocol module); (ii) a processor unit **114** in communication with the wireless communication module **110**; (iii) a non-volatile memory unit **122** in communication with the processor unit **114**; and (iv) a volatile memory **120** unit in communication with the processor unit **114**. The infrastructure wireless network may comprise a WLAN. The transceiver circuit **100** may receive digital audio from the data source **20** via the infrastructure wireless network **30** when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**. The transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to transition automatically to a pre-set infrastructure wireless network **30** that the data source **20** transitions to when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24** and when the pre-set infrastructure wireless network **30** is in range of both the earphone **10** and the data source **20**. In addition, the transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to transmit data via the ad hoc wireless network **24** to the data source **20** regarding one or more infrastructure wireless networks **30** detected by the transceiver circuit **100** when the earphone **10** and the data source **20** are communicating via the ad hoc wireless network **24**.

In addition, the transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to connect to a host server **40** via an available infrastructure wireless network **30** when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**. The earphone **10** may receive streaming digital audio from the host server **40** via the infrastructure wireless network **30**. In addition, the earphone **10** may receive a first network address for a first streaming digital audio content server **70** from the host server **40** via the infrastructure wireless network **30**. In addition, the earphone **10** may comprise a user control, such as button **11**, dial, pressure switch, or other type of user control, that, when activated, causes the earphone **10** to transmit an electronic request via the infrastructure wireless network **30** to the host server **40** for a second network address for a second streaming digital audio content server **70**.

In other embodiments, the present invention is directed to a system that comprises: (i) a data source **20** for wirelessly transmitting streaming digital audio; and (ii) a wireless earphone **10** that is in wireless communication with the data

source **20**. In yet other embodiments, the present invention is directed to a communication system that comprises: (i) a host server **40**; (ii) a first streaming digital audio content server **70** that is connected to the host server **40** via a data network **42**; and (iii) a wireless earphone **10** that is in communication with the host server **40** via a wireless network **30**. The host server **40** is programmed to transmit to the earphone **10** a first network address for the first streaming digital audio content server **70** on the data network **42**. The host server **40** and the streaming digital audio content server(s) **70** each may comprise one or more processor circuits and one or more memory circuits (e.g., ROM circuits and/or RAM circuits).

In yet another embodiment, the present invention is directed to a headset that comprises: (i) a first earphone **10*a*** that comprises one or more acoustic transducers **10*b*** for converting a first electrical signal to sound; and (ii) a second earphone **10*b***, connected to the first earphone **10*a***, wherein the second earphone **10*b*** comprises one or more acoustic transducers **10*b*** for converting a second electrical signal to sound. In one embodiment, the first earphone **10*a*** comprises: (i) a first antenna **108**; and (ii) a first transceiver circuit **100** in communication with the one or more acoustic transducers **106** of the first earphone **10*a*** and in communication with the first antenna **108**. The first transceiver circuit **100** is for receiving and transmitting wireless signals via the first antenna **108**, and for outputting the first electrical signal to the one or more acoustic transducers **10*b*** of the first earphone **10*a***. The first transceiver circuit **100** also may comprise firmware, which when executed by the first transceiver circuit **100**, causes the first transceiver circuit **100** to: (i) receive digital audio wirelessly from a data source **20** via an ad hoc wireless network **24** when the data source **20** is in wireless communication range with the first earphone **10*a*** via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the first earphone **10*a*** via the ad hoc wireless network **24**, transition automatically to receive digital audio via an infrastructure wireless network **30**.

In various implementations, the headset further may comprise a head band **19** that is connected to the first and second earphones **10**. In addition, the headset **19** further may comprise a microphone **104** having an output connected to the first transceiver circuit **100**. In one embodiment, the first transceiver circuit **100** is for outputting the second electrical signal to the one or more acoustic transducers **106** of the second earphone **10*b***. In another embodiment, the second earphone **10*b*** comprises: (i) a second antenna **108**; and (ii) a second transceiver circuit **100** in communication with the one or more acoustic transducers **106** of the second earphone **10*b*** and in communication with the second antenna **108**. The second transceiver circuit **100** is for receiving and transmitting wireless signals via the second antenna **108**, and for outputting the second electrical signal to the one or more acoustic transducers **106** of the second earphone **10*b***. The second transceiver circuit **100** may comprise firmware, which when executed by the second transceiver circuit **100**, causes the second transceiver circuit **100** to: (i) receive digital audio wirelessly from the data source **20** via the ad hoc wireless network **24** when the data source **20** is in wireless communication range with the second earphone **10*b*** via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the second earphone **10*b*** via the ad hoc wireless network **24**, transition automatically to receive digital audio via the infrastructure wireless network **30**.

In addition, according to various embodiments, the first earphone **10*a*** may comprise a first data port and the second earphone **10*b*** may comprise a second data port. In addition, the headset may further comprise an adapter or dongle **150** connected to the first data port of the first earphone **10*a*** and to the second data port of the second earphone **10*b***, wherein the adapter **150** comprises an output plug connector **152** for connecting to a remote device.

In addition, according to other embodiments, the present invention is directed to a method that comprises the steps of: (i) receiving, by a wireless earphone, via an ad hoc wireless network, digital audio from a data source when the data source is in wireless communication with the earphone via the ad hoc wireless network; (ii) converting, by the wireless earphone, the digital audio to sound; and (iii) when the data source is not in wireless communication with the earphone, transitioning automatically, by the earphone, to receive digital audio via an infrastructure wireless network.

In various implementations, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network may comprises transitioning automatically to receive digital audio from the data source via an infrastructure wireless network when the data source is not in wireless communication range with the earphone via the ad hoc wireless network. In addition, the method may further comprise the step of receiving by the wireless earphone from the data source via the ad hoc wireless network data regarding one or more infrastructure wireless networks detected by data source when the earphone and the data source are communicating via the ad hoc wireless network.

In addition, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network comprises may transitioning automatically to receive digital audio from a host sever via the infrastructure wireless network when the data source is not in wireless communication range with the earphone via the ad hoc wireless network. Additionally, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network may comprise: (i) receiving, by the wireless earphone via the infrastructure wireless network, from a host server connected to the infrastructure wireless network, a network address for a streaming digital audio content server; and (ii) connecting, by the wireless earphone, to the streaming digital audio content server using the network address received from the host server.

It is to be understood that the figures and descriptions of the embodiments have been simplified to illustrate elements that are relevant for a clear understanding of the embodiments, while eliminating, for purposes of clarity, other elements. For example, certain operating system details for the various computer-related devices and systems are not described herein. Those of ordinary skill in the art will recognize, however, that these and other elements may be desirable in a typical processor or computer system. Because such elements are well known in the art and because they do not facilitate a better understanding of the embodiments, a discussion of such elements is not provided herein.

In general, it will be apparent to one of ordinary skill in the art that at least some of the embodiments described herein may be implemented in many different embodiments of software, firmware and/or hardware. The software and firmware code may be executed by a processor or any other similar computing device. The software code or specialized control hardware that may be used to implement embodiments is not limiting. For example, embodiments described herein may be implemented in computer software using any

suitable computer software language type. Such software may be stored on any type of suitable computer-readable medium or media, such as, for example, a magnetic or optical storage medium. The operation and behavior of the embodiments may be described without specific reference to specific software code or specialized hardware components. The absence of such specific references is feasible, because it is clearly understood that artisans of ordinary skill would be able to design software and control hardware to implement the embodiments based on the present description with no more than reasonable effort and without undue experimentation.

Moreover, the processes associated with the present embodiments may be executed by programmable equipment, such as computers or computer systems and/or processors. Software that may cause programmable equipment to execute processes may be stored in any storage device, such as, for example, a computer system (nonvolatile) memory, an optical disk, magnetic tape, or magnetic disk. Furthermore, at least some of the processes may be programmed when the computer system is manufactured or stored on various types of computer-readable media.

A "computer," "computer system," "host," "host server," "server," or "processor" may be, for example and without limitation, a processor, microcomputer, minicomputer, server, mainframe, laptop, personal data assistant (PDA), wireless e-mail device, cellular phone, pager, processor, fax machine, scanner, or any other programmable device configured to transmit and/or receive data over a network. Such components may comprise: one or more processor circuits; and one more memory circuits, including ROM circuits and RAM circuits. Computer systems and computer-based devices disclosed herein may include memory for storing certain software applications used in obtaining, processing, and communicating information. It can be appreciated that such memory may be internal or external with respect to operation of the disclosed embodiments. The memory may also include any means for storing software, including a hard disk, an optical disk, floppy disk, ROM (read only memory), RAM (random access memory), PROM (programmable ROM), EEPROM (electrically erasable PROM) and/or other computer-readable media.

In various embodiments disclosed herein, a single component may be replaced by multiple components and multiple components may be replaced by a single component to perform a given function or functions. Except where such substitution would not be operative, such substitution is within the intended scope of the embodiments. Any servers described herein, such as the host server **40**, for example, may be replaced by a "server farm" or other grouping of networked servers (such as server blades) that are located and configured for cooperative functions. It can be appreciated that a server farm may serve to distribute workload between/among individual components of the farm and may expedite computing processes by harnessing the collective and cooperative power of multiple servers. Such server farms may employ load-balancing software that accomplishes tasks such as, for example, tracking demand for processing power from different machines, prioritizing and scheduling tasks based on network demand and/or providing backup contingency in the event of component failure or reduction in operability.

While various embodiments have been described herein, it should be apparent that various modifications, alterations, and adaptations to those embodiments may occur to persons skilled in the art with attainment of at least some of the advantages. The disclosed embodiments are therefore intended to include all such modifications, alterations, and adaptations without departing from the scope of the embodiments as set forth herein.

What is claimed is:

1. Headphones comprising:

a pair of first and second wireless earphones to be worn simultaneously by a user, wherein the first and second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected, wherein each of the first and second earphones comprises:

a body portion;

an earbud extending from the body portion that is inserted into an ear of the user when worn by the user;

a curved hanger bar connected to the body portion, wherein the curved hanger bar comprises a portion that rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user;

a wireless communication circuit for receiving and transmitting wireless signals;

a processor circuit connected to the wireless communication circuit;

at least one acoustic transducer for producing audible sound from the earbud;

a microphone for picking up utterances of a user of the headphones;

an antenna connected to the wireless communication circuit; and

a rechargeable power source; and

a docking station for holding at least the first wireless earphone, wherein the docking station comprises a power cable for connecting to an external device to power the docking station, and wherein the docking station is for charging at least the first wireless earphone when the first wireless earphone is placed in the docking station.

2. The headphones of claim **1**, wherein:

the wireless communication circuits are for receiving, wirelessly, streaming audio content;

the at least one acoustic transducers are for playing the streaming audio content; and

each of the first and second earphones comprises a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer.

3. The headphones of claim **1**, wherein the processor circuit for the first earphone is for, upon activation of a user control of the headphones, initiating transmission of a request to a remote network server that is remote from the headphones.

4. The headphones of claim **3**, wherein the processor circuit of the first earphone is further for receiving a response to the request.

5. The headphones of claim **1**, wherein the processor circuits are configured to transition from playing streaming audio content received wirelessly from a first digital audio source via a first communication link to playing streaming audio content received wirelessly from a second digital audio source via a second communication link based on, at least in part, a signal strength for the second wireless communication link.

6. The headphones of claim **5**, wherein:

the wireless communication circuits are for receiving, wirelessly, streaming audio content;

the at least one acoustic transducers are for playing the streaming audio content; and

each of the first and second earphones comprises a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer.

7. The headphones of claim **6**, wherein the processor circuit of each of the first and second earphones comprises:

a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone; and

a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

8. The headphones of claim **7**, wherein the rechargeable power source comprises a passive, wireless rechargeable power source.

9. The headphones of claim **1**, the processor circuits of the headphones are configured to receive firmware upgrades transmitted from a remote network server.

10. The headphones of claim **9**, wherein the headphone are configured to receive the firmware upgrades wirelessly.

11. The headphones of claim **10**, wherein the processor circuits are configured to transition from playing streaming audio content received wirelessly from a first digital audio source via a first communication link to playing streaming audio content received wirelessly from a second digital audio source via a second communication link based on, at least in part, a signal strength for the second wireless communication link.

12. The headphones of claim **11**, wherein the processor circuit of each of the first and second earphones comprises:

a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone; and

a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

13. The headphones of claim **12**, wherein:

the wireless communication circuits are for receiving, wirelessly, streaming audio content;

the at least one acoustic transducers are for playing the streaming audio content; and

each of the first and second earphones comprises a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer.

14. The headphones of claim **10**, wherein:

the wireless communication circuits are for receiving, wirelessly, streaming audio content;

the at least one acoustic transducers are for playing the streaming audio content; and

each of the first and second earphones comprises a buffer for caching the streaming audio content prior to being played by the at least one acoustic transducer.

15. The headphones of claim **1**, wherein the processor circuit of the first earphone is configured to:

process audible utterances by the user picked by the microphone in response to activation of the microphone by the user; and

transmit a communication based on the audible utterances via the Bluetooth wireless communication links.

16. The headphones of claim **1**, wherein the rechargeable power source comprises wirelessly chargeable circuit components.

17. The headphones of claim **1**, wherein the rechargeable power source comprises a passive, wireless rechargeable power source.

18. The headphones of claim **1**, wherein the processor circuit of each of the first and second earphones comprises:

a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone; and

a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

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(12) **United States Patent**
Koss et al.

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(54) **SYSTEM WITH WIRELESS EARPHONES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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CPC ... H04R 1/1016; H04R 25/554; H04R 1/1008
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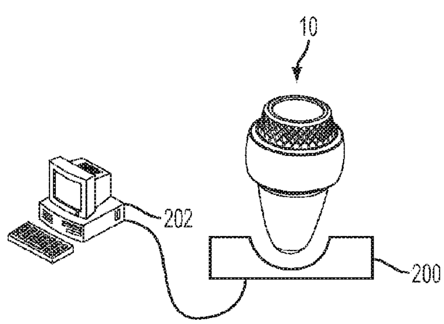
(57) **ABSTRACT**

Apparatus comprises adapter and speaker system. Adapter is configured to plug into port of personal digital audio player. Speaker system is in communication with adapter, and comprises multiple acoustic transducers, programmable processor circuit, and wireless communication circuit. In first operational mode, processor circuit receives, via adapter, and processes digital audio content from personal digital audio player into which adapter is plugged, and the multiple acoustic transducers output the received audio content from the personal digital audio player. In second operational mode, wireless communication circuit receives digital audio content from a remote digital audio source over a wireless network, processor circuit processes the digital audio content received from remote digital audio source, and the multiple acoustic transducers output the audio content received from the remote digital audio source.

20 Claims, 16 Drawing Sheets



APPLE 1001

Related U.S. Application Data

No. 16/182,927, filed on Nov. 7, 2018, now Pat. No. 10,368,155, which is a continuation of application No. 15/962,305, filed on Apr. 25, 2018, now Pat. No. 10,206,025, which is a continuation of application No. 15/650,362, filed on Jul. 14, 2017, now Pat. No. 9,986,325, which is a continuation of application No. 15/293,785, filed on Oct. 14, 2016, now Pat. No. 9,729,959, which is a continuation of application No. 15/082,040, filed on Mar. 28, 2016, now Pat. No. 9,497,535, which is a continuation of application No. 14/695,696, filed on Apr. 24, 2015, now Pat. No. 9,438,987, which is a continuation of application No. 13/609,409, filed on Sep. 11, 2012, now Pat. No. 9,049,502, which is a continuation of application No. 13/459,291, filed on Apr. 30, 2012, now Pat. No. 8,571,544, which is a continuation of application No. 12/936,488, filed as application No. PCT/US2009/039754 on Apr. 7, 2009, now Pat. No. 8,190,203.

(60) Provisional application No. 61/123,265, filed on Apr. 7, 2008.

(51) **Int. Cl.**

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H04M 1/02	(2006.01)
H04R 5/033	(2006.01)
H04R 5/04	(2006.01)
H03G 3/02	(2006.01)
H04R 1/02	(2006.01)
H04L 29/12	(2006.01)
H04H 20/95	(2008.01)
H03K 17/96	(2006.01)
H04W 4/80	(2018.01)
H04W 84/12	(2009.01)
H04W 84/18	(2009.01)
H04R 25/00	(2006.01)

(52) **U.S. Cl.**

CPC ***H04H 20/95*** (2013.01); ***H04L 61/6068*** (2013.01); ***H04M 1/0254*** (2013.01); ***H04R 1/02*** (2013.01); ***H04R 1/1091*** (2013.01); ***H04R 3/00*** (2013.01); ***H04R 5/033*** (2013.01); ***H04R 5/04*** (2013.01); ***H04W 4/80*** (2018.02); ***H04W 48/20*** (2013.01); *H03K 2217/960785* (2013.01); *H04R 25/554* (2013.01); *H04R 2201/103* (2013.01); *H04R 2201/107* (2013.01); *H04R 2225/55* (2013.01); *H04R 2420/07* (2013.01); *H04W 84/12* (2013.01); *H04W 84/18* (2013.01)

(58) **Field of Classification Search**

USPC 381/74, 77, 386, 71.6, 381, 59, 306, 309, 381/103; 455/556.1, 462, 66.1, 575.2, 455/41.2; 370/412, 338

See application file for complete search history.

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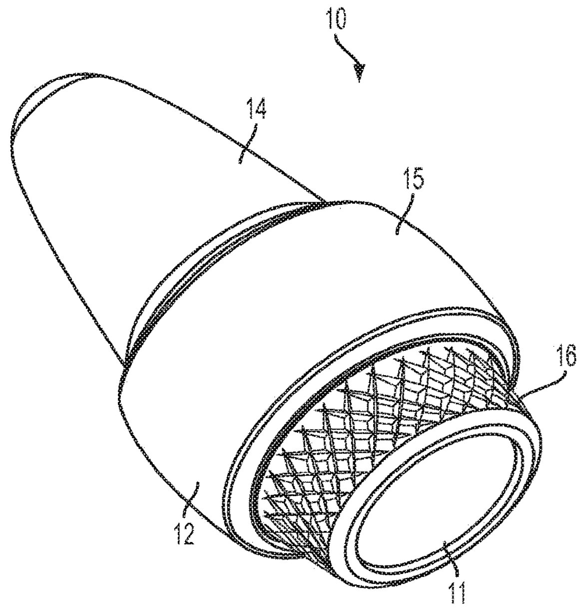


FIG. 1A

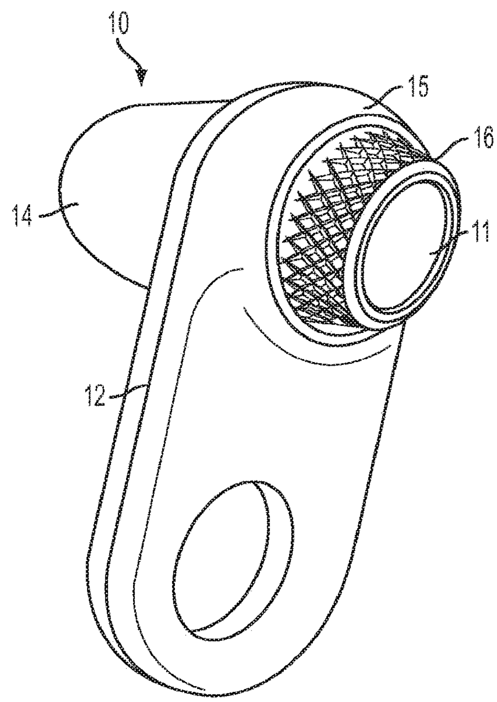


FIG. 1B

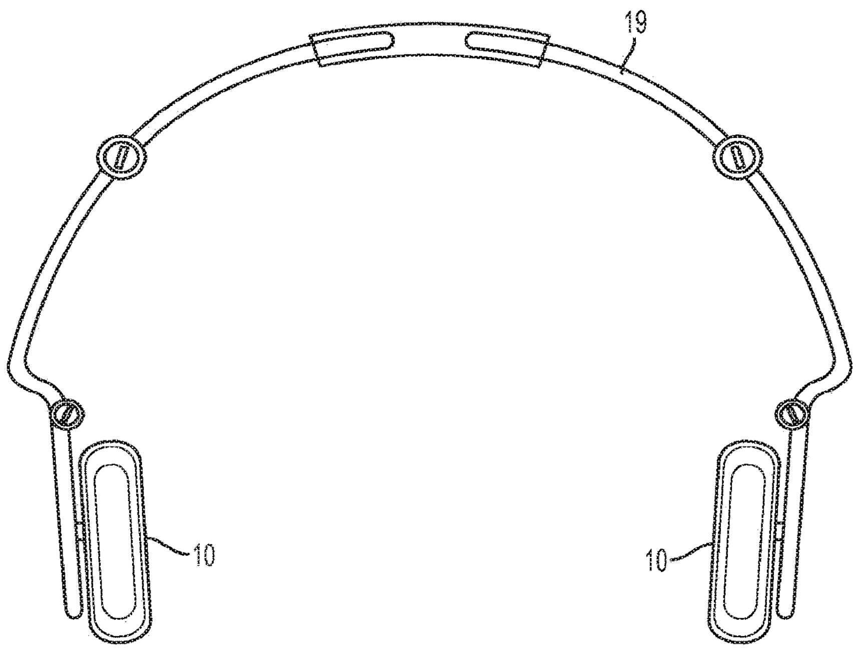


FIG. 1C

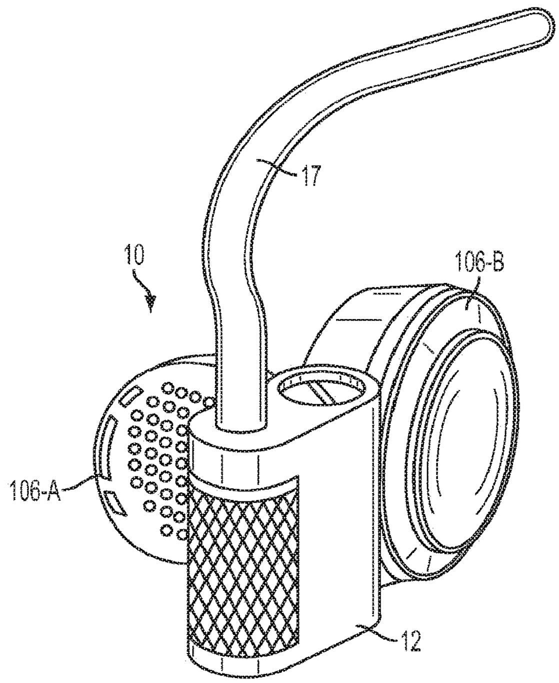


FIG. 1D

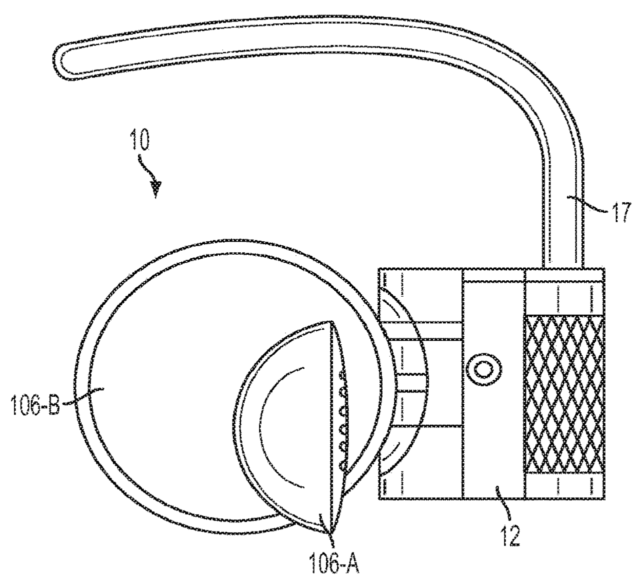


FIG. 1E

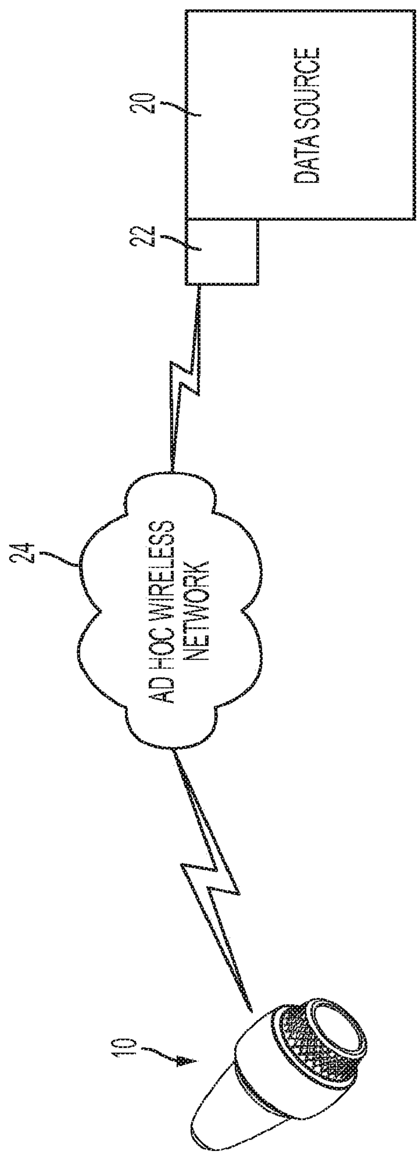


FIG. 2A

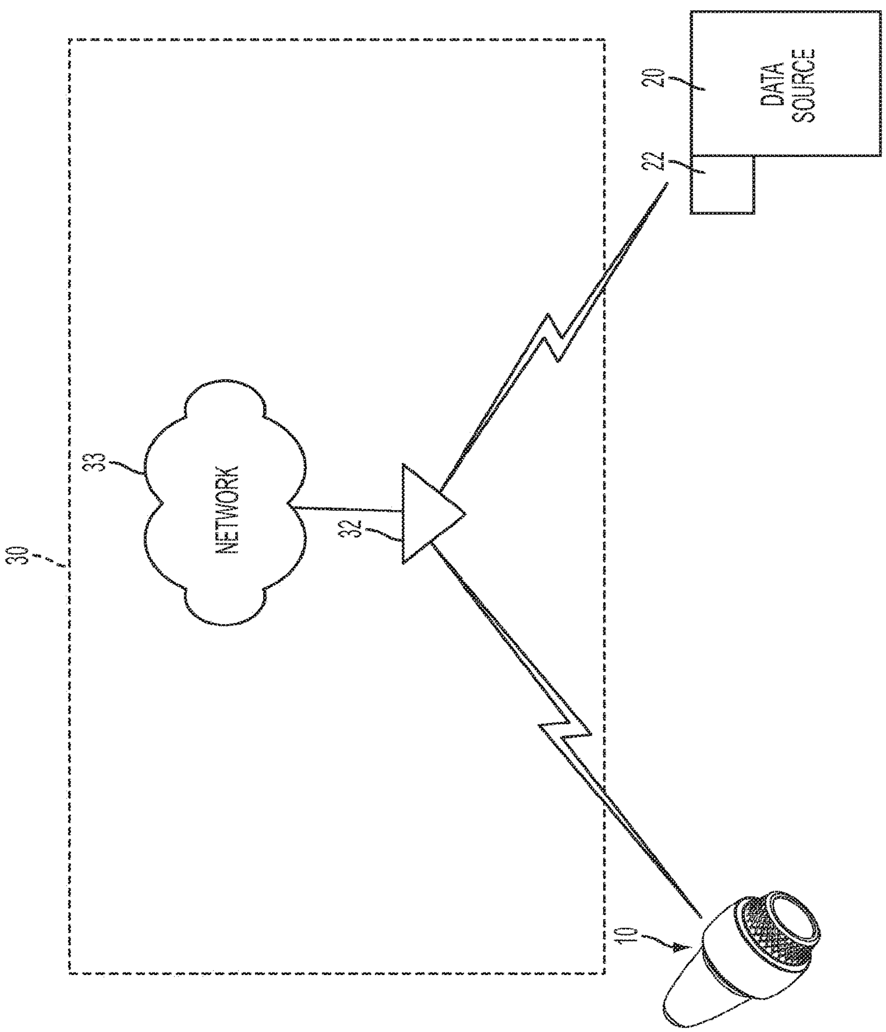


FIG. 2B

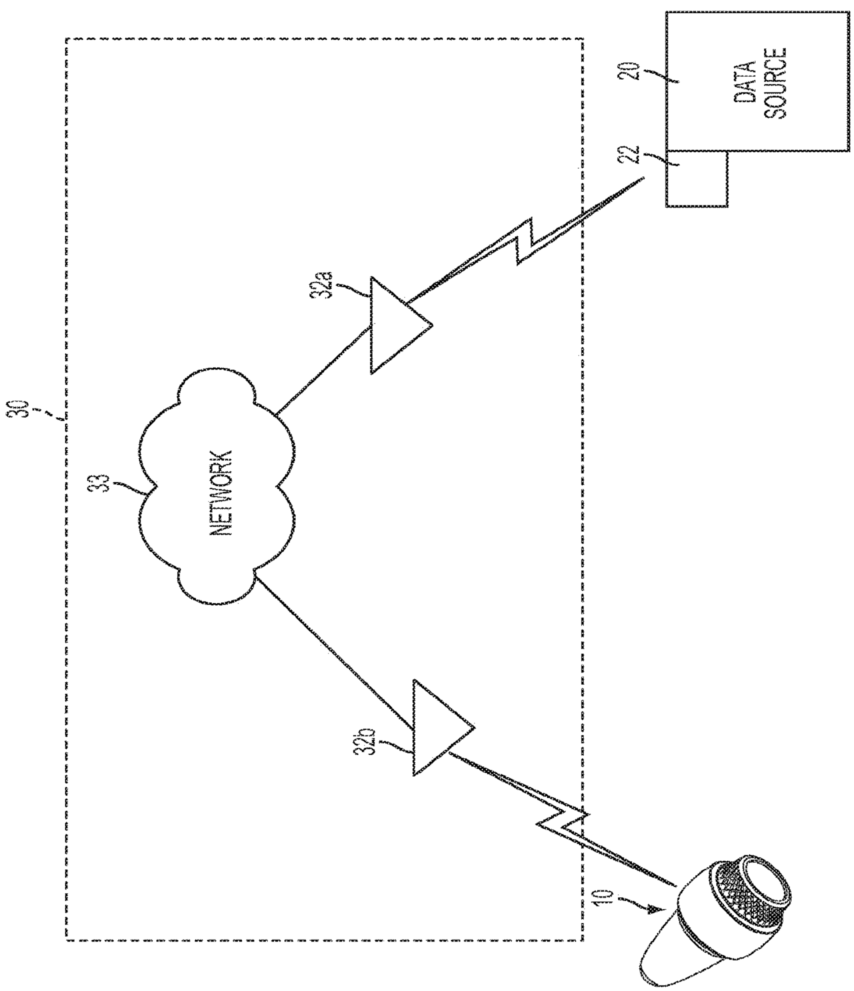


FIG. 2C

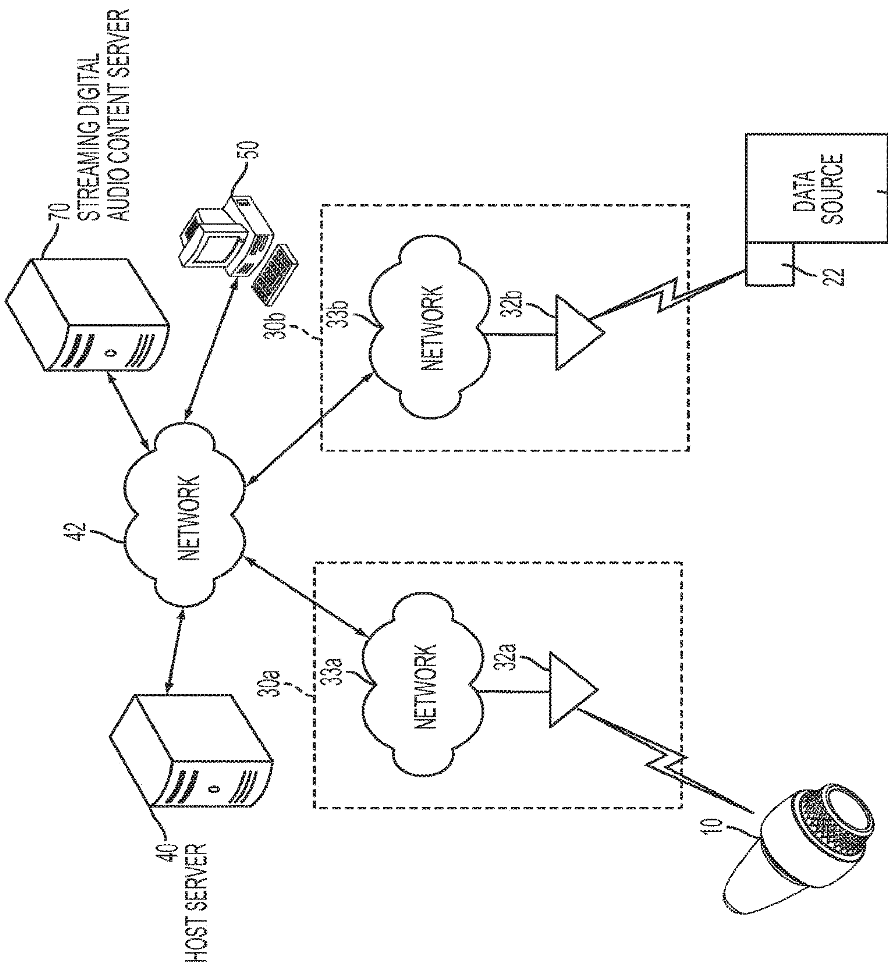

70
STREAMING DIGITAL
AUDIO CONTENT SERVER
50
42
NETWORK
30b
33b
NETWORK
32b
22
DATA
SOURCE
20
30a
33a
NETWORK
32a
40
HOST SERVER
10

FIG. 2D

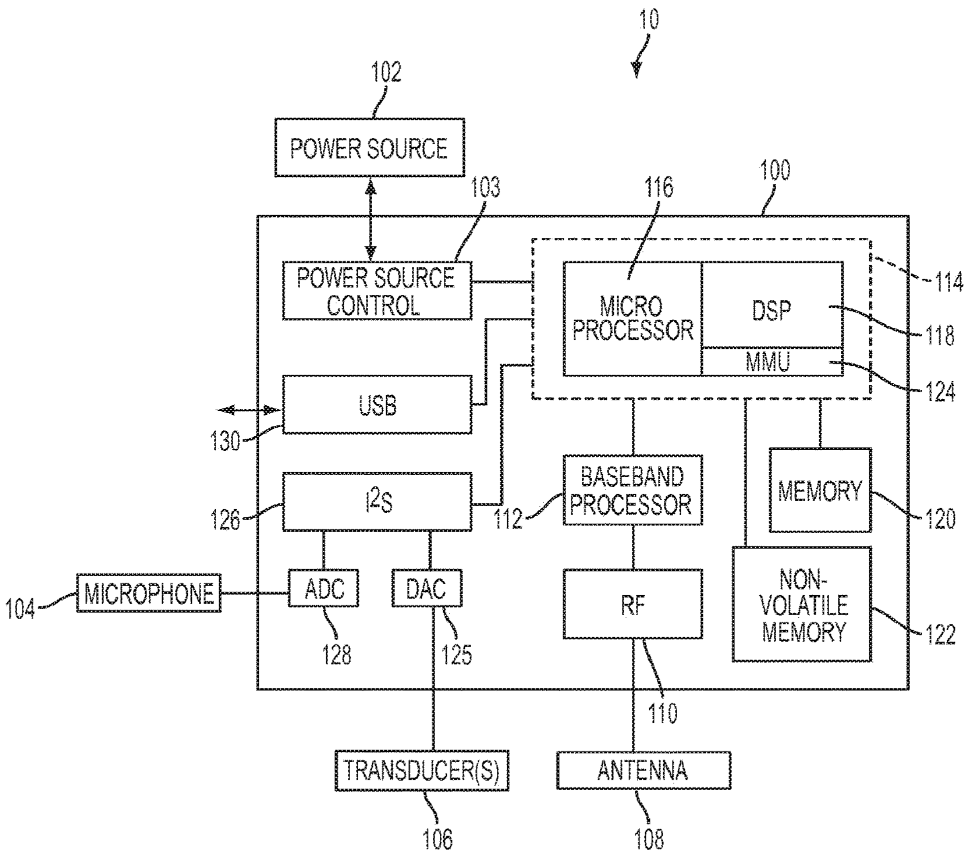

10
102
POWER SOURCE
103
116
100
POWER SOURCE CONTROL
MICRO PROCESSOR
DSP
MMU
114
118
124
USB
130
I2S
126
BASEBAND PROCESSOR
112
MEMORY
120
NON-VOLATILE MEMORY
122
104
MICROPHONE
ADC
DAC
RF
128
125
110
TRANSDUCER(S)
ANTENNA
106
108

FIG. 3

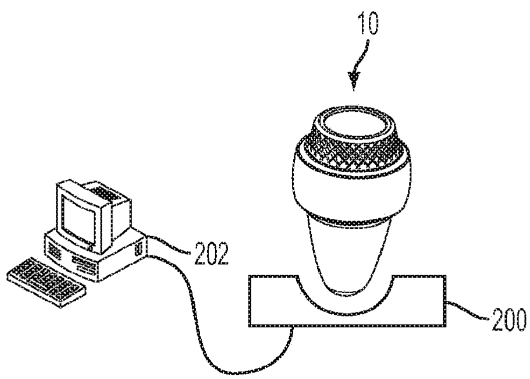


FIG. 4A

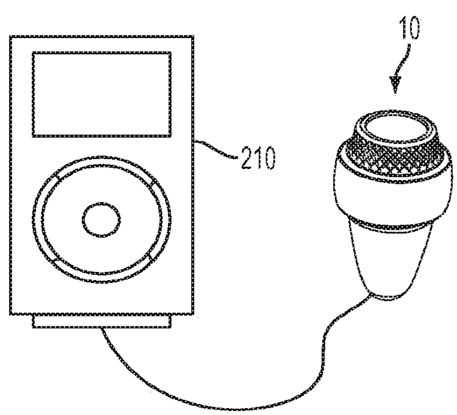


FIG. 4B

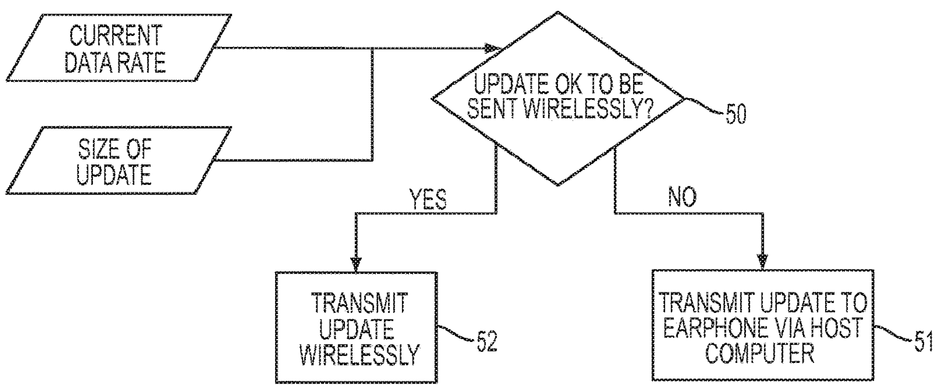
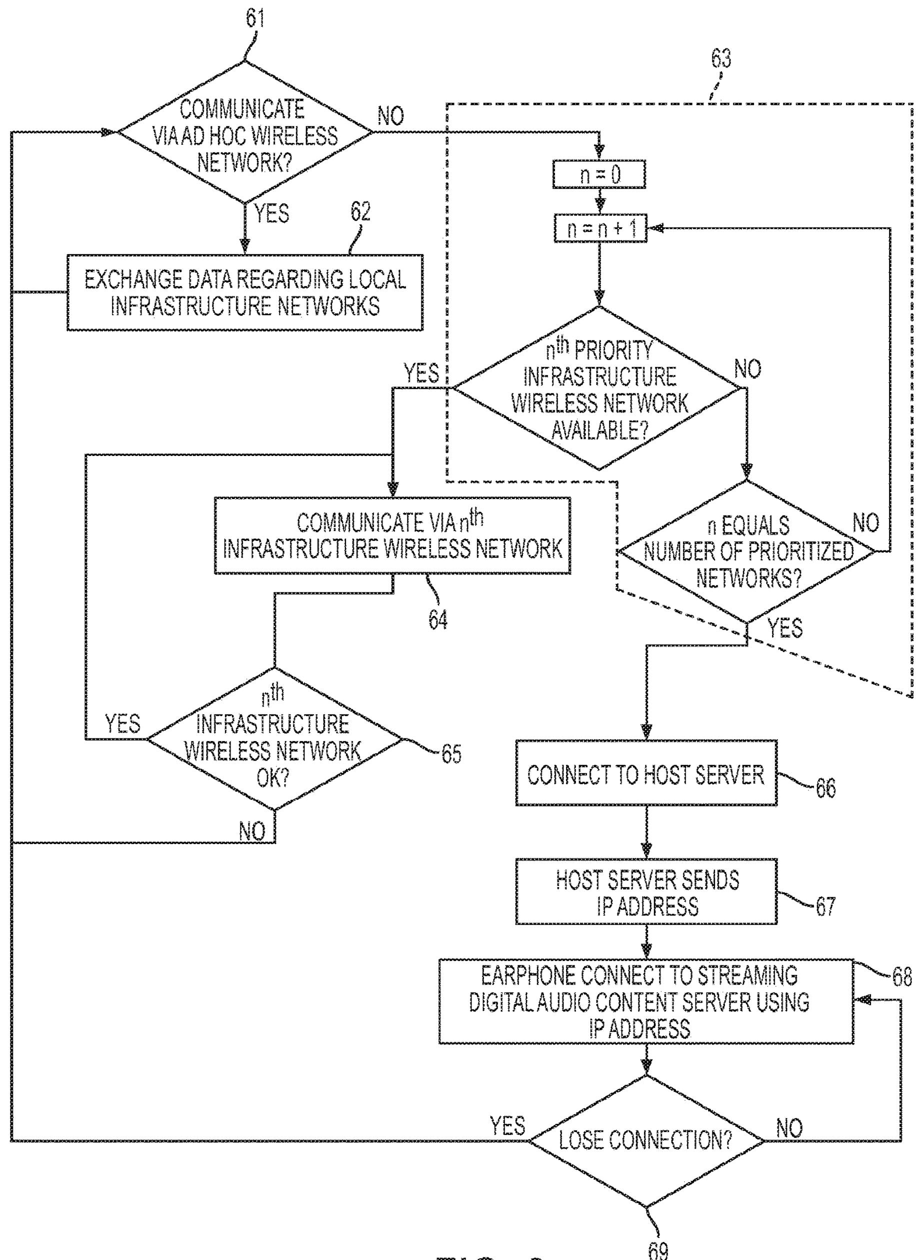

CURRENT DATA RATE
SIZE OF UPDATE
UPDATE OK TO BE SENT WIRELESSLY?
50
YES
NO
TRANSMIT UPDATE WIRELESSLY
52
TRANSMIT UPDATE TO EARPHONE VIA HOST COMPUTER
51

FIG. 5



61
COMMUNICATE VIA AD HOC WIRELESS NETWORK?
NO
YES
62
EXCHANGE DATA REGARDING LOCAL INFRASTRUCTURE NETWORKS
63
n = 0
n = n + 1
n^th PRIORITY INFRASTRUCTURE WIRELESS NETWORK AVAILABLE?
YES
NO
n EQUALS NUMBER OF PRIORITIZED NETWORKS?
NO
YES
COMMUNICATE VIA n^th INFRASTRUCTURE WIRELESS NETWORK
64
n^th INFRASTRUCTURE WIRELESS NETWORK OK?
YES
NO
65
CONNECT TO HOST SERVER
66
HOST SERVER SENDS IP ADDRESS
67
EARPHONE CONNECT TO STREAMING DIGITAL AUDIO CONTENT SERVER USING IP ADDRESS
68
LOSE CONNECTION?
YES
NO
69

FIG. 6

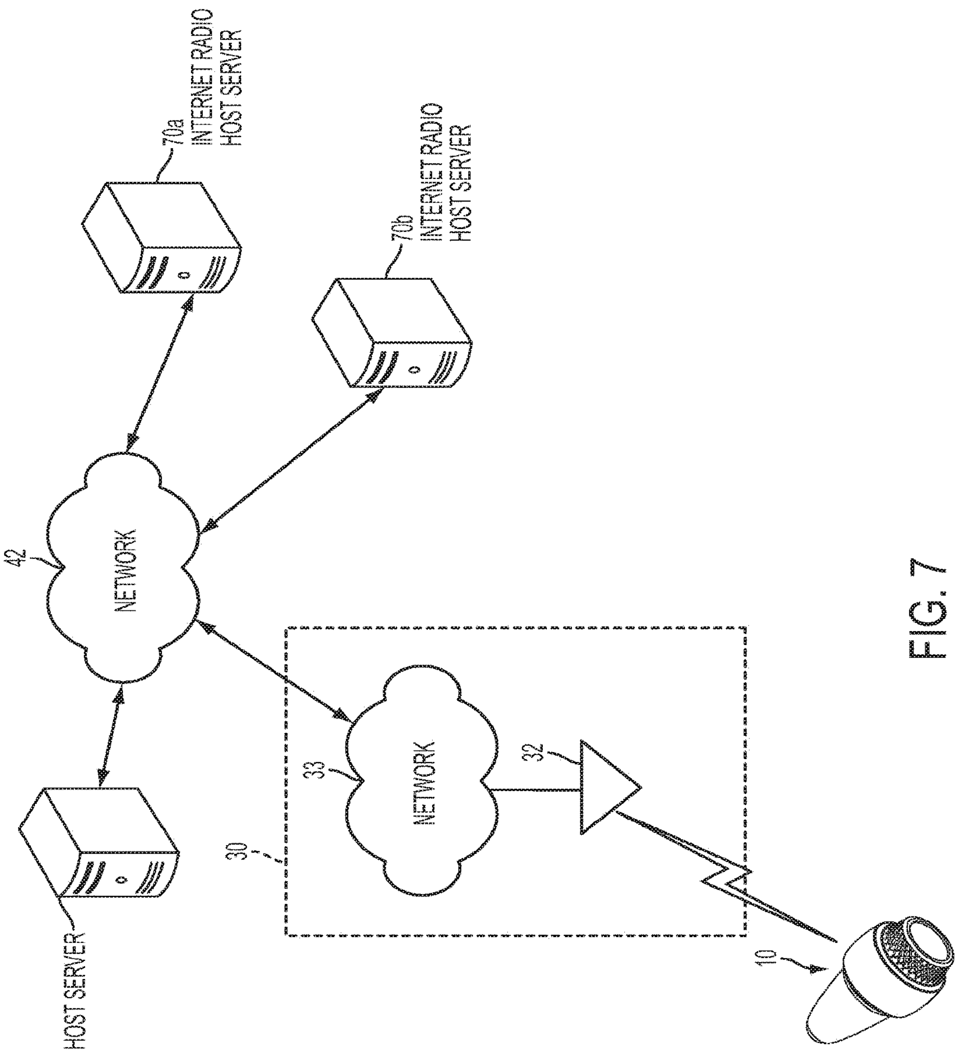
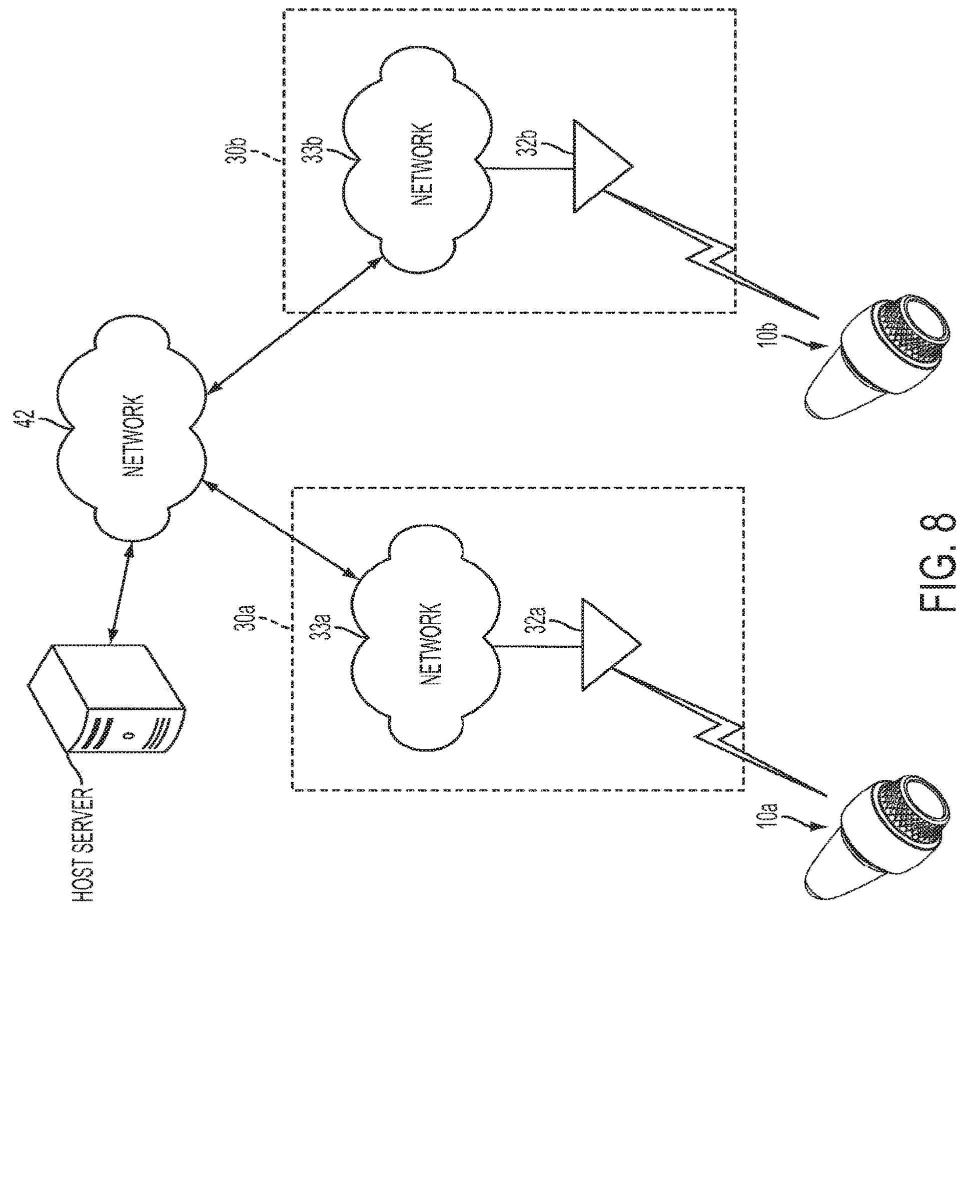

70a
INTERNET RADIO
HOST SERVER
70b
INTERNET RADIO
HOST SERVER
42
NETWORK
HOST SERVER
30
33
NETWORK
32
10

FIG. 7



30b
33b
NETWORK
32b
10b
42
NETWORK
30a
33a
NETWORK
32a
10a
HOST SERVER

FIG. 8

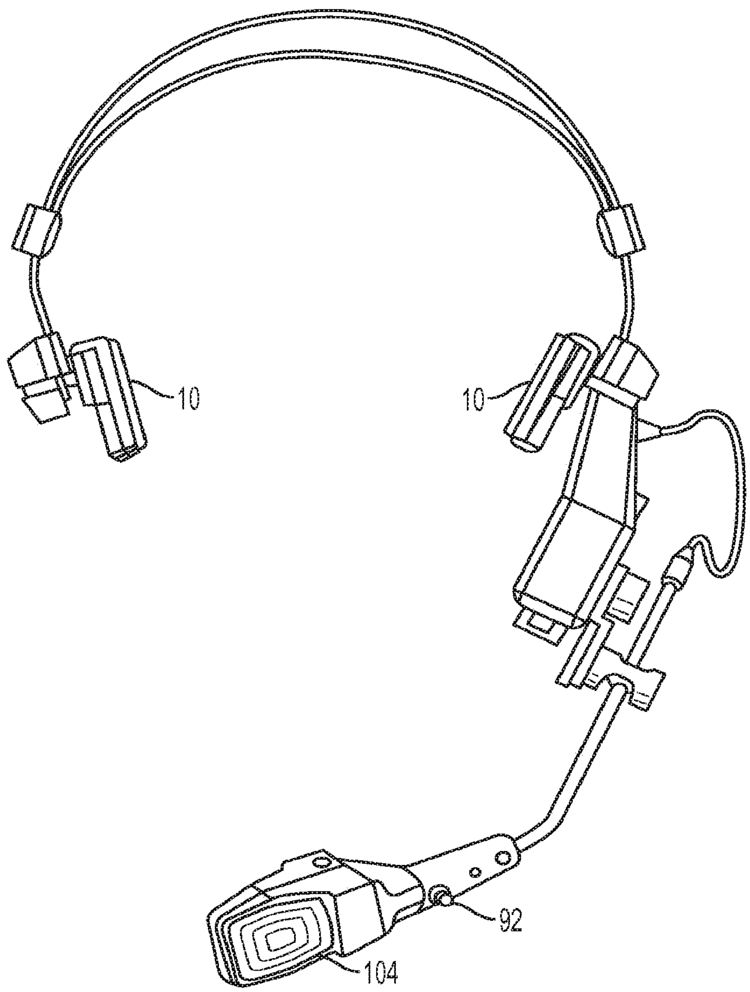


FIG. 9

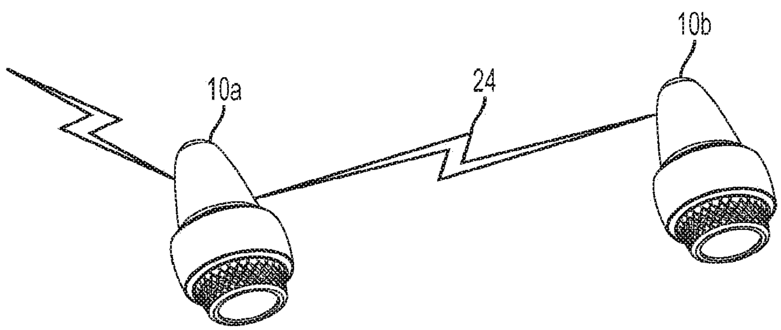


FIG. 10

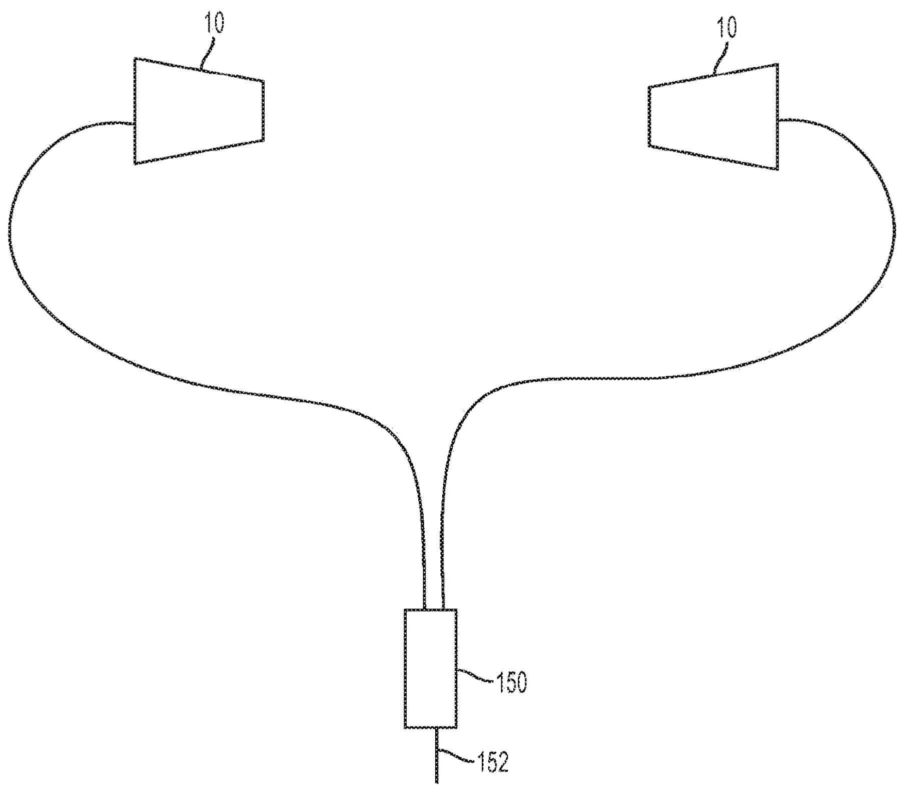


FIG. 11

SYSTEM WITH WIRELESS EARPHONES

PRIORITY CLAIM

The present application claims priority as a continuation to U.S. nonprovisional patent application Ser. No. 16/375,879, filed Apr. 5, 2019, which is a continuation of U.S. nonprovisional patent application Ser. No. 16/182,927, filed Nov. 7, 2018, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/962,305, filed Apr. 25, 2018, now U.S. Pat. No. 10,206,025, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/650,362, filed Jul. 14, 2017, now U.S. Pat. No. 9,986,325, issued May 29, 2018, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/293,785, filed Oct. 14, 2016, now U.S. Pat. No. 9,729,959, issued Aug. 8, 2017, which is a continuation of U.S. nonprovisional patent application Ser. No. 15/082,040, filed Mar. 28, 2016, now U.S. Pat. No. 9,497,535, issued Nov. 15, 2016, which is a continuation of U.S. nonprovisional patent application Ser. No. 14/695,696, filed Apr. 24, 2015, now U.S. Pat. No. 9,438,987, issued on Sep. 6, 2016, which is a continuation of U.S. nonprovisional patent application Ser. No. 13/609,409, filed Sep. 11, 2012, now U.S. Pat. No. 9,049,502, issued Jun. 2, 2015, which is a continuation of U.S. nonprovisional patent application Ser. No. 13/459,291, filed Apr. 30, 2012, now U.S. Pat. No. 8,571,544, issued Oct. 29, 2013, which is a continuation of U.S. patent application Ser. No. 12/936,488, filed Dec. 20, 2010, now U.S. Pat. No. 8,190,203, issued May 29, 2012, which is a national stage entry of PCT/US2009/039754, filed Apr. 7, 2009, which claims priority to U.S. provisional patent application Ser. No. 61/123,265, filed Apr. 7, 2008, all of which are incorporated herein by reference in their entireties.

CROSS-REFERENCE TO RELATED APPLICATIONS

U.S. nonprovisional patent application Ser. No. 14/031,938, filed Sep. 13, 2013, now U.S. Pat. No. 8,655,420, issued Feb. 18, 2014, is also a continuation of United States nonprovisional patent application Ser. No. 13/609,409, filed Sep. 11, 2012, now U.S. Pat. No. 9,049,502, mentioned above.

BACKGROUND

Digital audio players, such as MP3 players and iPods, that store and play digital audio files, are very popular. Such devices typically comprise a data storage unit for storing and playing the digital audio, and a headphone set that connects to the data storage unit, usually with a ¼" or a 3.5 mm jack and associated cord. Often the headphones are in-ear type headphones. The cord, however, between the headphones and the data storage unit can be cumbersome and annoying to users, and the length of the cord limits the physical distance between the data storage unit and the headphones. Accordingly, some cordless headphones have been proposed, such as the Monster iFreePlay cordless headphones from Apple Inc., which include a docking port on one of the earphones that can connect directly to an iPod Shuffle. Because they have the docking port, however, the Monster iFreePlay cordless headphones from Apple are quite large and are not in-ear type phones. Recently, cordless headphones that connect wirelessly via IEEE 802.11 to a WLAN-

ready laptop or personal computer (PC) have been proposed, but such headphones are also quite large and not in-ear type phones.

SUMMARY

In one general aspect, the present invention is directed to a wireless earphone that comprises a transceiver circuit for receiving streaming audio from a data source, such as a digital audio player or a computer, over an ad hoc wireless network. When the data source and the earphone are out of range via the ad hoc wireless network, they may transition automatically to a common infrastructure wireless network (e.g., a wireless LAN). If there is no common infrastructure wireless network for both the data source and the earphone, the earphone may connect via an available infrastructure wireless network to a host server. The host server may, for example, broadcast streaming audio to the earphone and/or transmit to the earphone a network address (e.g., an Internet Protocol (IP) address) for a network-connected content server that streams digital audio. The earphone may then connect to the content server using the IP address. The content server may be an Internet radio server, including, for example, an Internet radio server that broadcasts streaming audio from the data source or some other content.

These and other advantageous, unique aspects of the wireless earphone are described below.

FIGURES

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures, wherein:

FIGS. **1**A-**1**E are views of a wireless earphone according to various embodiments of the present invention;

FIGS. **2**A-**2**D illustrate various communication modes for a wireless earphone according to various embodiments of the present invention;

FIG. **3** is a block diagram of a wireless earphone according to various embodiments of the present invention;

FIGS. **4**A-**4**B show the wireless earphone connected to another device according to various embodiments of the present invention;

FIG. **5** is a diagram of a process implemented by a host server according to various embodiments of the present invention;

FIG. **6** is a diagram of a process implemented by the wireless earphone to transition automatically between wireless networks according to various embodiments of the present invention;

FIGS. **7**, **8** and **10** illustrate communication systems involving the wireless earphone according to various embodiments of the present invention;

FIG. **9** is a diagram of a headset including a wireless earphone and a microphone according to various embodiments of the present invention; and

FIG. **11** is a diagram of a pair of wireless earphones with a dongle according to various embodiments of the present invention.

DESCRIPTION

In one general aspect, the present invention is directed to a wireless earphone that receives streaming audio data via ad hoc wireless networks and infrastructure wireless networks, and that transitions seamlessly between wireless networks. The earphone may comprise one or more in-ear, on-ear, or

over-ear speaker elements. Two exemplary in-ear earphone shapes for the wireless earphone **10** are shown in FIGS. **1**A and **1**B, respectively, although in other embodiments the earphone may take different shapes and the exemplary shapes shown in FIGS. **1**A and **1**B are not intended to be limiting. In one embodiment, the earphone transitions automatically and seamlessly, without user intervention, between communication modes. That is, the earphone may transition automatically from an ad hoc wireless network to an infrastructure wireless network, without user intervention. As used herein, an "ad hoc wireless network" is a network where two (or more) wireless-capable devices, such as the earphone and a data source, communicate directly and wirelessly, without using an access point. An "infrastructure wireless network," on the other hand, is a wireless network that uses one or more access points to allow a wireless-capable device, such as the wireless earphone, to connect to a computer network, such as a LAN or WAN (including the Internet).

FIGS. **1**A and **1**B show example configurations for a wireless earphone **10** according to various embodiments of the present invention. The examples shown in FIGS. **1**A and **1**B are not limiting and other configurations are within the scope of the present invention. As shown in FIGS. **1**A and **1**B, the earphone **10** may comprise a body **12**. The body **12** may comprise an ear canal portion **14** that is inserted in the ear canal of the user of the earphone **10**. In various embodiments, the body **12** also may comprise an exterior portion **15** that is not inserted into user's ear canal. The exterior portion **15** may comprise a knob **16** or some other user control (such as a dial, a pressure-activated switch, lever, etc.) for adjusting the shape of the ear canal portion **14**. That is, in various embodiments, activation (e.g. rotation) of the knob **16** may cause the ear canal portion **14** to change shape so as to, for example, radially expand to fit snugly against all sides of the user's ear canal. Further details regarding such a shape-changing earbud earphone are described in application PCT/US08/88656, filed 31 Dec. 2008, entitled "Adjustable Shape Earphone," which is incorporated herein by reference in its entirety. The earphone **10** also may comprise a transceiver circuit housed within the body **12**. The transceiver circuit, described further below, may transmit and receive the wireless signals, including receive streaming audio for playing by the earphone **10**. The transceiver circuit may be housed in the exterior portion **15** of the earphone **10** and/or in the ear canal portion **14**.

Although the example earphones **10** shown in FIGS. **1**A and **1**B include a knob **16** for adjusting the shape of the ear canal portion **14**, the present invention is not so limited, and in other embodiments, different means besides a knob **16** may be used to adjust the ear canal portion **14**. In addition, in other embodiments, the earphone **10** may not comprise a shape-changing ear canal portion **14**.

In various embodiments, the user may wear two discrete wireless earphones **10**: one in each ear. In such embodiments, each earphone **10** may comprise a transceiver circuit. In such embodiments, the earphones **10** may be connected by a string or some other cord-type connector to keep the earphones **10** from being separated.

In other embodiments, as shown in FIG. **1**C, a headband **19** may connect the two (left and right) earphones **10**. The headband **19** may be an over-the-head band, as shown in the example of FIG. **1**C, or the headband may be a behind-the-head band. In embodiments comprising a headband **19**, each earphone **10** may comprise a transceiver circuit; hence, each earphone **10** may receive and transmit separately the wireless communication signals. In other embodiments comprising a headband **19**, only one earphone **10** may comprise the transceiver circuit, and a wire may run along the headband **19** to the other earphone **10** to connect thereby the transceiver circuit to the acoustic transducer in the earphone that does not comprise the transceiver circuit. The embodiment shown in FIG. **1**C comprises on-ear earphones **10**; in other embodiments, in-ear or over-ear earphones may be used.

In other embodiments, the earphone **10** may comprise a hanger bar **17** that allows the earphone **10** to clip to, or hang on, the user's ear, as shown in the illustrated embodiment of FIGS. **1**D-**1**E. FIG. **1**D is a perspective view of the earphone and FIG. **1**E is a side view according to one embodiment. As shown in the illustrated embodiment, the earphone **10** may comprise dual speaker elements **106**-A, **106**-B. One of the speaker elements (the smaller one) **106**-A is sized to fit into the cavum concha of the listener's ear and the other element (the larger one) **106**-B is not. The listener may use the hanger bar to position the earphone on the listener's ear. In that connection, the hanger bar may comprise a horizontal section that rests upon the upper external curvature of the listener's ear behind the upper portion of the auricula (or pinna). The earphone may comprise a knurled knob that allows the user to adjust finely the distance between the horizontal section of the hanger bar and the speaker elements, thereby providing, in such embodiments, another measure of adjustability for the user. More details regarding such a dual element, adjustable earphone may be found in U.S. provisional patent application Ser. No. 61/054,238, which is incorporated herein by reference in its entirety.

FIGS. **2**A-**2**D illustrate various communication modes for a wireless data communication system involving the earphone **10** according to embodiments of the present invention. As shown in FIG. **2**A, the system comprises a data source **20** in communication with the earphone **10** via an ad hoc wireless network **24**. The earphone **10**, via its transceiver circuit (described in more detail below), may communicate wirelessly with a data source **20**, which may comprise a wireless network adapter **22** for transmitting the digital audio wirelessly. For example, the data source **20** may be a digital audio player (DAP), such as an mp3 player or an iPod, or any other suitable digital audio playing device, such as a laptop or personal computer, that stores and/or plays digital audio files. In other embodiments, the data source **20** may generate analog audio, and the wireless network adapter **22** may encode the analog audio into digital format for transmission to the earphone **10**.

The wireless network adapter **22** may be an integral part of the data source **20**, or it may be a separate device that is connected to the data source **20** to provide wireless connectivity for the data source **20**. For example, the wireless network adapter **22** may comprise a wireless network interface card (WNIC) or other suitable transceiver that plugs into a USB port or other port or jack of the data source **20** (such as a TRS connector) to stream data, e.g., digital audio files, via a wireless network (e.g., the ad hoc wireless network **24** or an infrastructure wireless network). The digital audio transmitted from the data source **20** to the earphone **10** via the wireless networks may comprise compressed or uncompressed audio. Any suitable file format may be used for the audio, including mp3, lossy or lossless WMA, Vorbis, Musepack, FLAC, WAV, AIFF, AU, or any other suitable file format.

When in range, the data source **20** may communicate with the earphone **10** via the ad hoc wireless network **24** using any suitable wireless communication protocol, including Wi-Fi (e.g., IEEE 802.11a/b/g/n), WiMAX (IEEE 802.16), Bluetooth, Zigbee, UWB, or any other suitable wireless

communication protocol. For purposes of the description to follow, it is assumed that the data source **20** and the earphone **10** communicate using a Wi-Fi protocol, although the invention is not so limited and other wireless communication protocols may be used in other embodiments of the invention. The data source **20** and the earphone **10** are considered in range for the ad hoc wireless network **24** when the signal strengths (e.g., the RSSI) of the signals received by the two devices are above a threshold minimum signal strength level. For example, the data source **20** and the earphone **10** are likely to be in range for an ad hoc wireless network when then are in close proximity, such as when the wearer of the earphone **10** has the data source **20** on his/her person, such as in a pocket, strapped to their waist or arm, or holding the data source in their hand.

When the earphone **10** and the data source **20** are out of range for the ad hoc wireless network **24**, that is, when the received signals degrade below the threshold minimum signal strength level, both the earphone **10** and the data source **20** may transition automatically to communicate over an infrastructure wireless network (such as a wireless LAN (WLAN)) **30** that is in the range of both the earphone **10** and the data source **20**, as shown in FIG. **2**B. The earphone **10** and the data source **20** (e.g., the wireless network adapter **22**) may include firmware, as described further below, that cause the components to make the transition to a common infrastructure wireless network **30** automatically and seamlessly, e.g., without user intervention. The earphone **10** may cache the received audio in a buffer or memory for a time period before playing the audio. The cached audio may be played after the connection over the ad hoc wireless network is lost to give the earphone **10** and the data source **20** time to connect via the infrastructure wireless network.

For example, as shown in FIG. **2**B, the infrastructure network may comprise an access point **32** that is in the range of both the data source **20** and the earphone **10**. The access point **32** may be an electronic hardware device that acts as a wireless access point for, and that is connected to, a wired and/or wireless data communication network **33**, such as a LAN or WAN, for example. The data source **20** and the earphone **10** may both communicate wirelessly with the access point **32** using the appropriate network data protocol (a Wi-Fi protocol, for example). The data source **20** and the earphone **10** may both transition automatically to an agreed-upon WLAN **30** that is in the range of both devices when they cannot communicate satisfactorily via the ad hoc wireless network **24**. A procedure for specifying an agreed-upon infrastructure wireless network **30** is described further below. Alternatively, the infrastructure wireless network **30** may have multiple access points **32***a-b*, as shown in FIG. **2**C. In such an embodiment, the data source **20** may communicate wirelessly with one access point **32***b* and the earphone **10** may communicate wirelessly with another access point **32***a* of the same infrastructure wireless network **30**. Again, the data source **20** and the earphone **10** may transition to an agreed-upon WLAN.

If there is no suitable common infrastructure wireless network over which the earphone **10** and the data source **20** can communicate, as shown in FIG. **2**D, the earphone **10** may transition to communicate with an access point **32***a* for an available (first) wireless network (e.g., WLAN) **30***a* that is in the range of the earphone **10**. In this mode, the earphone **10** may connect via the wireless network **30***a* to a network-enabled host server **40**. The host server **40** may be connected to the wireless network **30***a* via an electronic data communication network **42**, such as the Internet. In one mode, the host server **40** may transmit streaming digital audio via the networks **33***a*, **42** to the earphone **10**. In another mode, the host server **40** may transmit to the earphone **10** a network address, such as an Internet Protocol (IP) address, for a streaming digital audio content server **70** on the network **42**. Using the received IP address, the earphone **10** may connect to the streaming digital audio content server **70** via the networks **30***a*, **42** to receive and process digital audio from the streaming digital audio content server **70**.

The digital audio content server **70** may be, for example, an Internet radio station server. The digital audio content server **70** may stream digital audio over the network **42** (e.g., the Internet), which the earphone **10** may receive and process. In one embodiment, the streaming digital audio content server **70** may stream digital audio received by the streaming digital audio content server **70** from the data source **20**. For example, where the data source **20** is a wireless-capable device, such as a portable DAP, the data source **20** may connect to the streaming digital audio content server **70** via a wireless network **30***b* and the network **42**. Alternatively, where for example the data source **20** is non-wireless-capable device, such as a PC, the data source **20** may have a direct wired connection to the network **42**. After being authenticated by the streaming digital audio content server **70**, the data source **20** may stream digital audio to the streaming digital audio content server **70**, which may broadcast the received digital audio over the network **42** (e.g., the Internet). In such a manner, the user of the earphone **10** may listen to audio from the data source **20** even when (i) the earphone **10** and the data source **20** are not in communication via an ad hoc wireless network **24** and (ii) the earphone **10** and the data source **20** are not in communication via a common local infrastructure wireless network **30**.

FIG. **3** is a block diagram of the earphone **10** according to various embodiments of the present invention. In the illustrated embodiment, the earphone **10** comprises a transceiver circuit **100** and related peripheral components. As shown in FIG. **3**, the peripheral components of the earphone **10** may comprise a power source **102**, a microphone **104**, one or more acoustic transducers **106** (e.g., speakers), and an antenna **108**. The transceiver circuit **100** and some of the peripheral components (such as the power source **102** and the acoustic transducers **106**) may be housed within the body **12** of the earphone **10** (see FIG. **1**). Other peripheral components, such as the microphone **104** and the antenna **108** may be external to the body **12** of the earphone **10**. In addition, some of the peripheral components, such as the microphone **104**, are optional in various embodiments.

In various embodiments, the transceiver circuit **100** may be implemented as a single integrated circuit (IC), such as a system-on-chip (SoC), which is conducive to miniaturizing the components of the earphone **10**, which is advantageous if the earphone **10** is to be relatively small in size, such as an in-ear earphone (see FIGS. **1**A-**1**B for example). In alternative embodiments, however, the components of the transceiver circuit **100** could be realized with two or more discrete ICs or other components, such as separate ICs for the processors, memory, and RF (e.g., Wi-Fi) module, for example.

The power source **102** may comprise, for example, a rechargeable or non-rechargeable battery (or batteries). In other embodiments, the power source **102** may comprise one or more ultracapacitors (sometimes referred to as supercapacitors) that are charged by a primary power source. In embodiments where the power source **102** comprises a rechargeable battery cell or an ultracapacitor, the battery cell or ultracapacitor, as the case may be, may be charged for use,

for example, when the earphone **10** is connected to a docking station or computer. The docking station may be connected to or part of a computer device, such as a laptop computer or PC. In addition to charging the rechargeable power source **102**, the docking station and/or computer may facilitate downloading of data to and/or from the earphone **10**. In other embodiments, the power source **102** may comprise capacitors passively charged with RF radiation, such as described in U.S. Pat. No. 7,027,311. The power source **102** may be coupled to a power source control module **103** of transceiver circuit **100** that controls and monitors the power source **102**.

The acoustic transducer(s) **106** may be the speaker element(s) for conveying the sound to the user of the earphone **10**. According to various embodiments, the earphone **10** may comprise one or more acoustic transducers **106**. For embodiments having more than one transducer, one transducer may be larger than the other transducer, and a crossover circuit (not shown) may transmit the higher frequencies to the smaller transducer and may transmit the lower frequencies to the larger transducer. More details regarding dual element earphones are provided in U.S. Pat. No. 5,333,206, assigned to Koss Corporation, which is incorporated herein by reference in its entirety.

The antenna **108** may receive and transmit the wireless signals from and to the wireless networks **24**, **30**. A RF (e.g., Wi-Fi) module **110** of the transceiver circuit **100** in communication with the antenna **108** may, among other things, modulate and demodulate the signals transmitted from and received by the antenna **108**. The RF module **110** communicates with a baseband processor **112**, which performs other functions necessary for the earphone **10** to communicate using the Wi-Fi (or other communication) protocol.

The baseband processor **112** may be in communication with a processor unit **114**, which may comprise a microprocessor **116** and a digital signal processor (DSP) **118**. The microprocessor **116** may control the various components of the transceiver circuit **100**. The DSP **114** may, for example, perform various sound quality enhancements to the digital audio received by the baseband processor **112**, including noise cancellation and sound equalization. The processor unit **114** may be in communication with a volatile memory unit **120** and a non-volatile memory unit **122**. A memory management unit **124** may control the processor unit's access to the memory units **120**, **122**. The volatile memory **122** may comprise, for example, a random access memory (RAM) circuit. The non-volatile memory unit **122** may comprise a read only memory (ROM) and/or flash memory circuits. The memory units **120**, **122** may store firmware that is executed by the processor unit **114**. Execution of the firmware by the processor unit **114** may provide various functionality for the earphone **10**, such as the automatic transition between wireless networks as described herein. The memory units **120**, **122** may also cache received digital audio.

A digital-to-analog converter (DAC) **125** may convert the digital audio from the processor unit **114** to analog form for coupling to the acoustic transducer(s) **106**. An I^2S interface **126** or other suitable serial or parallel bus interface may provide the interface between the processor unit **114** and the DAC **125**. An analog-to-digital converter (ADC) **128**, which also communicates with the I^2S interface **126**, may convert analog audio signals picked up by the microphone **104** for processing by the processor unit **114**.

The transceiver circuit **100** also may comprise a USB or other suitable interface **130** that allows the earphone **10** to be connected to an external device via a USB cable or other suitable link. As shown in FIG. **4**A, the external device may be a docking station **200** connected to a computer device **202**. Also, in various embodiments, the earphone **10** could be connected directly to the computer **202** without the docking station **200**. In addition, the external device may be a DAP **210**, as shown in FIG. **4**B. In that way, the earphone **10** could connect directly to a data source **20**, such as the DAP **210** or the computer **202**, through the USB port **130**. In addition, through the USB port **130**, the earphone **10** may connect to a PC **202** or docking station **202** to charge up the power source **102** and/or to get downloads (e.g., data or firmware).

According to various embodiments, the earphone **10** may have an associated web page that a user may access through the host server **40** (see FIG. **2**D) or some other server. An authenticated user could log onto the website from a client computing device **50** (e.g., laptop, PC, handheld computer device, etc., including the data source **20**) (see FIG. **2**D) to access the web page for the earphone **10** to set various profile values for the earphone **10**. For example, at the web site, the user could set various content features and filters, as well as adjust various sound control features, such as treble, bass, frequency settings, noise cancellation settings, etc. In addition, the user could set preferred streaming audio stations, such as preferred Internet radio stations or other streaming audio broadcasts. That way, instead of listening to streaming audio from the data source **20**, the user could listen to Internet radio stations or other streaming audio broadcasts received by the earphone **10**. In such an operating mode, the earphone user, via the web site, may prioritize a number of Internet radio stations or other broadcast sources (hosted by streaming digital audio content servers **70**). With reference to FIG. **7**, the host server **40** may send the IP address for the earphone user's desired (e.g., highest priority) Internet radio station to the earphone **10**. A button **11** on the earphone **10**, such as on the rotating dial **16** as shown in the examples of FIGS. **1**A and **1**B, may allow the user to cycle through the preset preferred Internet radio stations. That is, for example, when the user presses the button **11**, an electronic communication may be transmitted to the host server **40** via the wireless network **30**, and in response to receiving the communication, the host server **40** may send the IP address for the user's next highest rated Internet radio station via the network **42** to the earphone **10**. The earphone **10** may then connect to the streaming digital audio content server **70** for that Internet radio station using the IP address provided by the host server **40**. This process may be repeated, e.g., cycled through, for each preset Internet radio station configured by the user of the earphone **10**.

At the web site for the earphone **10** hosted on the host server **40**, in addition to establishing the identification of digital audio sources (e.g., IDs for the user's DAP or PC) and earphones, the user could set parental or other user controls. For example, the user could restrict certain Internet radio broadcasts based on content or parental ratings, etc. That is, for example, the user could configure a setting through the web site that prevents the host server **40** from sending an IP address for a streaming digital audio content server **70** that broadcasts explicit content based on a rating for the content. In addition, if a number of different earphones **10** are registered to the same user, the user could define separate controls for the different earphones **10** (as well as customize any other preferences or settings particular to the earphones **10**, including Internet radio stations, sound quality settings, etc. that would later be downloaded to the earphones **10**). In addition, in modes where the host server **40** streams audio to the earphone **10**, the host server

40 may log the files or content streamed to the various earphones **10**, and the user could view at the web site the files or content that were played by the earphones **10**. In that way, the user could monitor the files played by the earphones **10**.

In addition, the host server **40** may provide a so-called eavesdropping function according to various embodiments. The eavesdropping service could be activated via the web site. When the service is activated, the host server **40** may transmit the content that it is delivering to a first earphone **10***a* to another, second earphone **10***b*, as shown in FIG. **8**. Alternatively, the host server **40** may transmit to the second earphone **10***b* the most recent IP address for a streaming digital audio content server **70** that was sent to the first earphone **10***a*. The second earphone **10***b* may then connect to the streaming digital audio content server **70** that the first earphone **10***a* is currently connected. That way, the user of the second earphone **10***b*, which may be a parent, for example, may directly monitor the content being received by the first earphone **10***a*, which may belong to a child of the parent.

This function also could be present in the earphones **10** themselves, allowing a parent (or other user) to join an ad-hoc wireless network and listen to what their child (or other listener) is hearing. For example, with reference to FIG. **10**, a first earphone **10***a* may receive wireless audio, such as from the data source **20** or some other source, such as the host server **40**. The first earphone **10***a* may be programmed with firmware to broadcast the received audio to a second earphone **10***b* via an ad hoc wireless network **24**. That way, the wearer of the second earphone **10***b* can monitor in real-time the content being played by the first earphone **10***a*.

At the web site, the user may also specify the identification number ("ID") of their earphone(s) **10**, and the host server **40** may translate the ID to the current internet protocol (IP) addresses for the earphone **10** and for the data source **20**. This allows the user to find his or her data source **20** even when it is behind a firewall or on a changing IP address. That way, the host server **40** can match the audio from the data source **20** to the appropriate earphone **10** based on the specified device ID. The user also could specify a number of different data sources **20**. For example, the user's DAP may have one specified IP address and the user's home (or work) computer may have another specified IP address. Via the web site hosted by the host server **40**, the user could specify or prioritize from which source (e.g., the user's DAP or computer) the earphone **10** is to receive content.

The host server **40** (or some other server) may also push firmware upgrades and/or data updates to the earphone **10** using the IP addresses of the earphone **10** via the networks **30**, **42**. In addition, a user could download the firmware upgrades and/or data updates from the host server **40** to the client computing device **202** (see FIG. **4**A) via the Internet, and then download the firmware upgrades and/or data updates to the earphone **10** when the earphone **10** is connected to the client computer device **202** (such as through a USB port and/or the docking station **200**).

Whether the downloads are transmitted wirelessly to the earphone **10** or via the client computing device **202** may depend on the current data rate of the earphone **10** and the quantity of data to be transmitted to the earphone **10**. For example, according to various embodiments, as shown in the process flow of FIG. **5**, the host server **40** may be programmed, at step **50**, to make a determination, based on the current data rate for the earphone **10** and the size of the update, whether the update should be pushed to the earphone

10 wirelessly (e.g., via the WLAN **30***a* in FIG. **2**D). If the update is too large and/or the current data rate is too low that the performance of the earphone **10** will be adversely affected, the host server **40** may refrain from pushing the update to the earphone **10** wirelessly and wait instead to download the update to the client computing device **202** at step **51**. Conversely, if the host server **40** determines that, given the size of the update and the current data rate for the earphone **10** that the performance of the earphone **10** will not be adversely affected, the host server **40** may transmit the update wirelessly to the earphone **10** at step **52**.

As mentioned above, the processor unit **114** of the speakerphones **14** may be programmed, via firmware stored in the memory **120**, **122**, to have the ability to transition automatically from the ad hoc wireless network **24** to an infrastructure wireless network **30** (such as a WLAN) when the quality of the signal on the ad hoc wireless network **24** degrades below a suitable threshold (such as when the data source **20** is out of range for an ad hoc wireless network). In that case, the earphone **10** and the data source **20** may connect to a common infrastructure wireless network (e.g., WLAN) (see, for example, FIGS. **2**B-**2**C). Through the web site for the earphone **10**, described above, the user could specify a priority of infrastructure wireless networks **30** for the data source **20** and the earphone **10** to connect to when the ad hoc wireless network **24** is not available. For example, the user could specify a WLAN servicing his/her residence first, a WLAN servicing his/her place of employment second, etc. During the time that the earphone **10** and the data source **20** are connected via the ad hoc wireless network **24**, the earphone **10** and the data source **20** may exchange data regarding which infrastructure networks are in range. When the earphone **10** and the data source **20** are no longer in range for the ad hoc wireless network **24** (that is, for example, the signals between the device degrade below an acceptable level), they may both transition automatically to the highest prioritized infrastructure wireless network whose signal strength is above a certain threshold level. That way, even though the earphone **10** and the data source **20** are out of range for the ad hoc wireless network **24**, the earphone **10** may still receive the streaming audio from the data source **20** via the infrastructure wireless network **30** (see FIGS. **2**B-**2**C).

When none of the preferred infrastructure networks is in range, the earphone **10** may connect automatically to the host server **40** via an available infrastructure wireless network **30** (see FIG. **2**D), e.g., the infrastructure wireless network **30** having the highest RSSI and to which the earphone **10** is authenticated to use. The host server **40**, as mentioned above, may transmit IP addresses to the earphone **10** for streaming digital audio content servers **70** or the host sever **40** may stream digital audio to the earphone **10** itself when in this communication mode.

FIG. **6** is a diagram of the process flow, according to one embodiment, implemented by the transceiver circuit **100** of the earphone **10**. The process shown in FIG. **6** may be implemented in part by the processor unit **114** executing firmware stored in a memory unit **120**, **122** of the transceiver circuit **100**. At step **61**, the earphone **10** may determine if it can communicate with the data source **20** via an ad hoc wireless network **24**. That is, the earphone **10** may determine if the strength of the wireless signals from the data source **20** exceed some minimum threshold. If so, the data source **20** and the earphone **10** may communicate wirelessly via the ad hoc wireless network **24** (see FIG. **2**A). While in this communication mode, at step **62**, the data source **20** and the earphone **10** also may exchange data regarding the local

infrastructure wireless networks, if any, in the range of the data source **20** and the earphone **10**, respectively. For example, the earphone **10** may transmit the ID of local infrastructure wireless networks **30** that the earphone **10** can detect whose signal strength (e.g., RSSI) exceeds some minimum threshold level. Similarly, the data source **20** may transmit the ID the local infrastructure wireless networks **30** that the data source **20** can detect whose signal strength (e.g., RSSI) exceeds some minimum threshold level. The earphone **10** may save this data in a memory unit **120**, **122**. Similarly, the data source **20** may store in memory the wireless networks that the earphone **10** is detected.

The data source **20** and the earphone **10** may continue to communicate via the ad hoc wireless network mode **24** until they are out of range (e.g., the signal strengths degrade below a minimum threshold level). If an ad hoc wireless network **24** is not available at block **61**, the transceiver circuit **100** and the data source **20** may execute a process, shown at block **63**, to connect to the user's highest prioritized infrastructure wireless network **30**. For example, of the infrastructure wireless networks whose signal strength exceeded the minimum threshold for both the earphone **10** and the data source **20** determined at step **62**, the earphone **10** and the data source **20** may both transition to the infrastructure wireless network **30** having the highest priority, as previously set by the user (seen FIGS. **2**B-**2**C, for example). For example, if the user's highest prioritized infrastructure wireless network **30** is not available, but the user's second highest prioritized infrastructure wireless network **30** is, the earphone **10** and the data source **20** may both transition automatically to the user's second highest prioritized infrastructure wireless network **30** at block **64**. As shown by the loop with block **65**, the earphone **10** and the data source **20** may continue to communicate via one of the user's prioritized infrastructure wireless networks **30** as long as the infrastructure wireless network **30** is available. If the infrastructure wireless network becomes unavailable, the process may return to block **61**.

If, however, no ad hoc wireless network and none of the user's prioritized infrastructure wireless networks are available, the earphone **10** may transition automatically to connect to the host server **40** at block **66** (see FIG. **2**D) using an available infrastructure wireless network **30**. At block **67**, the host server **40** may transmit an IP address to the earphone **10** for one of the streaming digital audio content servers **70**, and at block **68** the earphone **10** may connect to the streaming digital audio content server **70** using the received IP address. At step **69**, as long as the earphone **10** is connected to the streaming digital audio content server **70**, the earphone **10** may continue to communicate in this mode. However, if the earphone **10** loses its connection to the digital audio content server **70**, the process may return to block **61** in one embodiment. As mentioned above, at block **67**, instead of sending an IP address for a streaming digital audio content server **70**, the host server **40** may stream digital audio to the earphone **10**. The user, when configuring their earphone **10** preferences via the web site, may specify and/or prioritize whether the host server **40** is to send IP addresses for the streaming digital audio content servers **70** and/or whether the host server **40** is to stream audio to the earphone **10** itself.

In another embodiment, the earphone **10** may be programmed to transition automatically to the host server **40** when the earphone **10** and the data source **20** are not in communication via the ad hoc wireless network **24**. That is, in such an embodiment, the earphone **10** may not try to connect via a local infrastructure wireless network **30** with the data source **20**, but instead transition automatically to connect to the host server **40** (see FIG. **2**D).

In various embodiments, as shown in FIG. **1**B, the button **11** or other user selection device that allows the wearer of the earphone **10** to indicate approval and/or disapproval of songs or other audio files listened to by the wearer over an Internet radio station. The approval/disapproval rating, along with metadata for the song received by the earphone **10** with the streaming audio, may be transmitted from the transceiver circuit **100** of the earphone **10** back to the host server **40**, which may log the songs played as well as the ratings for the various songs/audio files. In addition to being able to view the logs at the website, the host server **40** (or some other server) may send an email or other electronic communication to the earphone user, at a user specified email address or other address, which the user might access from their client communication device **50** (see FIG. **2**D). The email or other electronic communication may contain a listing of the song/audio files for which the user gave approval ratings using the button **11** or other user selection device. Further, the email or other electronic communication may provide a URL link for a URL at which the user could download song/audio files that the user rated (presumably song/audio files for which the user gave an approval rating). In some instances, the user may be required to pay a fee to download the song/audio file.

The user song ratings also may be used by the host server **40** to determine the user's musical preferences and offer new music that the user might enjoy. More details about generating user play lists based on song ratings may be found in published U.S. patent applications Pub. No. 2006/0212444, Pub. No. 2006/0206487, and Pub. No. 2006/0212442, and U.S. Pat. No. 7,003,515, which are incorporated herein by reference in their entirety.

In addition or alternatively, the user could log onto a web site hosted by the host server **40** (or some other server) to view the approval/disapproval ratings that the user made via the button **11** on the earphone **10**. The web site may provide the user with the option of downloading the rated songs/audio files (for the host server **40** or some other server system) to their client computer device **50**. The user could then have their earphone **10** connect to their client computer device **50** as a data source **20** via an ad hoc wireless network **24** (see FIG. **2**A) or via an infrastructure wireless network (see FIGS. **2**B-**2**D) to listen to the downloaded songs. In addition, the user could download the song files from their client computer device **50** to their DAP and listen to the downloaded song files from their DAP by using their DAP as the data source **20** in a similar manner.

Another application of the headsets may be in vehicles equipped with Wi-Fi or other wireless network connectivity. Published PCT application WO 2007/136620, which is incorporated herein by reference, discloses a wireless router for providing a Wi-Fi or other local wireless network for a vehicle, such as a car, truck, boat, bus, etc. In a vehicle having a Wi-Fi or other local wireless network, the audio for other media systems in the vehicle could be broadcast over the vehicle's wireless network. For example, if the vehicle comprises a DVD player, the audio from the DVD system could be transmitted to the router and broadcast over the vehicle's network. Similarly, the audio from terrestrial radio stations, a CD player, or an audio cassette player could be broadcast over the vehicle's local wireless network. The vehicle's passengers, equipped with the earphones **10**, could cycle through the various audio broadcasts (including the broadcasts from the vehicle's media system as well as broadcasts from the host server **40**, for example) using a

selection button **11** on the earphone **10**. The vehicle may also be equipped with a console or terminal, etc., through which a passenger could mute all of the broadcasts for direct voice communications, for example.

As described above, the earphones **10** may also include a microphone **104**, as shown in the example of FIG. **9**. The headset **90** shown in FIG. **9** includes two earphones **10**, both of which may include a transceiver circuit **100** or only one of which may include the transceiver circuit, as discussed above. The microphone **104** could be used to broadcast communications from one earphone wearer to another earphone wearer. For example, one wearer could activate the microphone by pressing a button **92** on the headset **90**. The headset **90** may then transmit a communication via an ad hoc wireless network **24** or other wireless network to a nearby recipient (or recipients) equipped with a headset **90** with a transceiver circuit **100** in one or both of the earphones **10**. When such communication is detected by the recipient's headset **90**, the streaming audio received over the wireless network by the recipient's headset **90** may be muted, and the intercom channel may be routed to the transducer(s) of the recipient's headset **90** for playing for the recipient. This functionality may be valuable and useful where multiple wearers of the headsets **90** are in close proximity, such as on motorcycles, for example.

Another exemplary use of the earphones **10** is in a factory, warehouse, construction site, or other environment that might be noisy. Persons (e.g., workers) in the environment could use the earphones **10** for protection from the surrounding noise of the environment. From a console or terminal, a person (e.g., a supervisor) could select a particular recipient for a communication over the Wi-Fi network (or other local wireless network). The console or terminal may have buttons, dials, or switches, etc., for each user/recipient, or it could have one button or dial through which the sender could cycle through the possible recipients. In addition, the console or terminal could have a graphical user interface, through which the sender may select the desired recipient(s).

As mentioned above, the earphones **10** may comprise a USB port. In one embodiment, as shown in FIG. **11**, the user may use an adapter **150** that connects to the USB port of each earphone **10**. The adapter **150** may also have a plug connector **152**, such as a 3.5 mm jack, which allows the user to connect the adapter **150** to devices having a corresponding port for the connector **152**. When the earphones **10** detect a connection via their USB interfaces in such a manner, the Wi-Fi (or other wireless protocol) components may shut down or go into sleep mode, and the earphones **10** will route standard headphone level analog signals to the transducer(s) **106**. This may be convenient in environments where wireless communications are not permitted, such as airplanes, but where there is a convenient source of audio contact. For example, the adapter **150** could plug into a person's DAP. The DSP **118** of the earphone **10** may still be operational in such a non-wireless mode to provide noise cancellation and any applicable equalization.

The examples presented herein are intended to illustrate potential and specific implementations of the embodiments. It can be appreciated that the examples are intended primarily for purposes of illustration for those skilled in the art. No particular aspect of the examples is/are intended to limit the scope of the described embodiments.

According to various embodiments, therefore, the present invention is directed to an earphone **10** that comprises a body **12**, where the body **12** comprises: (i) at least one acoustic transducer **106** for converting an electrical signal to sound; (ii) an antenna **108**; and (iii) a transceiver circuit **100** in communication with the at least one acoustic transducer **106** and the antenna **108**. The transceiver circuit **100** is for receiving and transmitting wireless signals via the antenna **108**, and the transceiver circuit **100** is for outputting the electrical signal to the at least one acoustic transducer **106**. The wireless transceiver circuit also comprises firmware, which when executed by the transceiver circuit, causes the transceiver circuit to: (i) receive digital audio wirelessly from a data source **20** via an ad hoc wireless network **24** when the data source **20** is in wireless communication range with the earphone **10** via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**, transition automatically to receive digital audio via an infrastructure wireless network **30**.

According to various implementations, the data source may comprise a portable digital audio player, such as an MP3 player, iPod, or laptop computer, or a nonportable digital audio player, such as a personal computer. In addition, the transceiver circuit **100** may comprise: (i) a wireless communication module **110** (such as a Wi-Fi or other wireless communication protocol module); (ii) a processor unit **114** in communication with the wireless communication module **110**; (iii) a non-volatile memory unit **122** in communication with the processor unit **114**; and (iv) a volatile memory **120** unit in communication with the processor unit **114**. The infrastructure wireless network may comprise a WLAN. The transceiver circuit **100** may receive digital audio from the data source **20** via the infrastructure wireless network **30** when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**. The transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to transition automatically to a pre-set infrastructure wireless network **30** that the data source **20** transitions to when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24** and when the pre-set infrastructure wireless network **30** is in range of both the earphone **10** and the data source **20**. In addition, the transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to transmit data via the ad hoc wireless network **24** to the data source **20** regarding one or more infrastructure wireless networks **30** detected by the transceiver circuit **100** when the earphone **10** and the data source **20** are communicating via the ad hoc wireless network **24**.

In addition, the transceiver circuit firmware, when executed by the transceiver circuit **100**, may cause the transceiver circuit **100** of the earphone **10** to connect to a host server **40** via an available infrastructure wireless network **30** when the data source **20** is not in wireless communication range with the earphone **10** via the ad hoc wireless network **24**. The earphone **10** may receive streaming digital audio from the host server **40** via the infrastructure wireless network **30**. In addition, the earphone **10** may receive a first network address for a first streaming digital audio content server **70** from the host server **40** via the infrastructure wireless network **30**. In addition, the earphone **10** may comprise a user control, such as button **11**, dial, pressure switch, or other type of user control, that, when activated, causes the earphone **10** to transmit an electronic request via the infrastructure wireless network **30** to the host server **40** for a second network address for a second streaming digital audio content server **70**.

In other embodiments, the present invention is directed to a system that comprises: (i) a data source **20** for wirelessly

transmitting streaming digital audio; and (ii) a wireless earphone **10** that is in wireless communication with the data source **20**. In yet other embodiments, the present invention is directed to a communication system that comprises: (i) a host server **40**; (ii) a first streaming digital audio content server **70** that is connected to the host server **40** via a data network **42**; and (iii) a wireless earphone **10** that is in communication with the host server **40** via a wireless network **30**. The host server **40** is programmed to transmit to the earphone **10** a first network address for the first streaming digital audio content server **70** on the data network **42**. The host server **40** and the streaming digital audio content server(s) **70** each may comprise one or more processor circuits and one or more memory circuits (e.g., ROM circuits and/or RAM circuits).

In yet another embodiment, the present invention is directed to a headset that comprises: (i) a first earphone **10***a* that comprises one or more acoustic transducers **10***b* for converting a first electrical signal to sound; and (ii) a second earphone **10***b*, connected to the first earphone **10***a*, wherein the second earphone **10***b* comprises one or more acoustic transducers **10***b* for converting a second electrical signal to sound. In one embodiment, the first earphone **10***a* comprises: (i) a first antenna **108**; and (ii) a first transceiver circuit **100** in communication with the one or more acoustic transducers **106** of the first earphone **10***a* and in communication with the first antenna **108**. The first transceiver circuit **100** is for receiving and transmitting wireless signals via the first antenna **108**, and for outputting the first electrical signal to the one or more acoustic transducers **10***b* of the first earphone **10***a*. The first transceiver circuit **100** also may comprise firmware, which when executed by the first transceiver circuit **100**, causes the first transceiver circuit **100** to: (i) receive digital audio wirelessly from a data source **20** via an ad hoc wireless network **24** when the data source **20** is in wireless communication range with the first earphone **10***a* via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the first earphone **10***a* via the ad hoc wireless network **24**, transition automatically to receive digital audio via an infrastructure wireless network **30**.

In various implementations, the headset further may comprise a head band **19** that is connected to the first and second earphones **10**. In addition, the headset **19** further may comprise a microphone **104** having an output connected to the first transceiver circuit **100**. In one embodiment, the first transceiver circuit **100** is for outputting the second electrical signal to the one or more acoustic transducers **106** of the second earphone **10***b*. In another embodiment, the second earphone **10***b* comprises: (i) a second antenna **108**; and (ii) a second transceiver circuit **100** in communication with the one or more acoustic transducers **106** of the second earphone **10***b* and in communication with the second antenna **108**. The second transceiver circuit **100** is for receiving and transmitting wireless signals via the second antenna **108**, and for outputting the second electrical signal to the one or more acoustic transducers **106** of the second earphone **10***b*. The second transceiver circuit **100** may comprise firmware, which when executed by the second transceiver circuit **100**, causes the second transceiver circuit **100** to: (i) receive digital audio wirelessly from the data source **20** via the ad hoc wireless network **24** when the data source **20** is in wireless communication range with the second earphone **10***b* via the ad hoc wireless network **24**; and (ii) when the data source **20** is not in wireless communication range with the second earphone **10***b* via the ad hoc wireless network **24**,

transition automatically to receive digital audio via the infrastructure wireless network **30**.

In addition, according to various embodiments, the first earphone **10***a* may comprise a first data port and the second earphone **10***b* may comprise a second data port. In addition, the headset may further comprise an adapter or dongle **150** connected to the first data port of the first earphone **10***a* and to the second data port of the second earphone **10***b*, wherein the adapter **150** comprises an output plug connector **152** for connecting to a remote device.

In addition, according to other embodiments, the present invention is directed to a method that comprises the steps of: (i) receiving, by a wireless earphone, via an ad hoc wireless network, digital audio from a data source when the data source is in wireless communication with the earphone via the ad hoc wireless network; (ii) converting, by the wireless earphone, the digital audio to sound; and (iii) when the data source is not in wireless communication with the earphone, transitioning automatically, by the earphone, to receive digital audio via an infrastructure wireless network.

In various implementations, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network may comprises transitioning automatically to receive digital audio from the data source via an infrastructure wireless network when the data source is not in wireless communication range with the earphone via the ad hoc wireless network. In addition, the method may further comprise the step of receiving by the wireless earphone from the data source via the ad hoc wireless network data regarding one or more infrastructure wireless networks detected by data source when the earphone and the data source are communicating via the ad hoc wireless network.

In addition, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network comprises may transitioning automatically to receive digital audio from a host sever via the infrastructure wireless network when the data source is not in wireless communication range with the earphone via the ad hoc wireless network. Additionally, the step of transitioning automatically by the earphone to receive digital audio via an infrastructure wireless network may comprise: (i) receiving, by the wireless earphone via the infrastructure wireless network, from a host server connected to the infrastructure wireless network, a network address for a streaming digital audio content server; and (ii) connecting, by the wireless earphone, to the streaming digital audio content server using the network address received from the host server.

It is to be understood that the figures and descriptions of the embodiments have been simplified to illustrate elements that are relevant for a clear understanding of the embodiments, while eliminating, for purposes of clarity, other elements. For example, certain operating system details for the various computer-related devices and systems are not described herein. Those of ordinary skill in the art will recognize, however, that these and other elements may be desirable in a typical processor or computer system. Because such elements are well known in the art and because they do not facilitate a better understanding of the embodiments, a discussion of such elements is not provided herein.

In general, it will be apparent to one of ordinary skill in the art that at least some of the embodiments described herein may be implemented in many different embodiments of software, firmware and/or hardware. The software and firmware code may be executed by a processor or any other similar computing device. The software code or specialized control hardware that may be used to implement embodi-

ments is not limiting. For example, embodiments described herein may be implemented in computer software using any suitable computer software language type. Such software may be stored on any type of suitable computer-readable medium or media, such as, for example, a magnetic or optical storage medium. The operation and behavior of the embodiments may be described without specific reference to specific software code or specialized hardware components. The absence of such specific references is feasible, because it is clearly understood that artisans of ordinary skill would be able to design software and control hardware to implement the embodiments based on the present description with no more than reasonable effort and without undue experimentation.

Moreover, the processes associated with the present embodiments may be executed by programmable equipment, such as computers or computer systems and/or processors. Software that may cause programmable equipment to execute processes may be stored in any storage device, such as, for example, a computer system (nonvolatile) memory, an optical disk, magnetic tape, or magnetic disk. Furthermore, at least some of the processes may be programmed when the computer system is manufactured or stored on various types of computer-readable media.

A "computer," "computer system," "host," "host server," "server," or "processor" may be, for example and without limitation, a processor, microcomputer, minicomputer, server, mainframe, laptop, personal data assistant (PDA), wireless e-mail device, cellular phone, pager, processor, fax machine, scanner, or any other programmable device configured to transmit and/or receive data over a network. Such components may comprise: one or more processor circuits; and one more memory circuits, including ROM circuits and RAM circuits. Computer systems and computer-based devices disclosed herein may include memory for storing certain software applications used in obtaining, processing, and communicating information. It can be appreciated that such memory may be internal or external with respect to operation of the disclosed embodiments. The memory may also include any means for storing software, including a hard disk, an optical disk, floppy disk, ROM (read only memory), RAM (random access memory), PROM (programmable ROM), EEPROM (electrically erasable PROM) and/or other computer-readable media.

In various embodiments disclosed herein, a single component may be replaced by multiple components and multiple components may be replaced by a single component to perform a given function or functions. Except where such substitution would not be operative, such substitution is within the intended scope of the embodiments. Any servers described herein, such as the host server **40**, for example, may be replaced by a "server farm" or other grouping of networked servers (such as server blades) that are located and configured for cooperative functions. It can be appreciated that a server farm may serve to distribute workload between/among individual components of the farm and may expedite computing processes by harnessing the collective and cooperative power of multiple servers. Such server farms may employ load-balancing software that accomplishes tasks such as, for example, tracking demand for processing power from different machines, prioritizing and scheduling tasks based on network demand and/or providing backup contingency in the event of component failure or reduction in operability.

While various embodiments have been described herein, it should be apparent that various modifications, alterations, and adaptations to those embodiments may occur to persons skilled in the art with attainment of at least some of the advantages. The disclosed embodiments are therefore intended to include all such modifications, alterations, and adaptations without departing from the scope of the embodiments as set forth herein.

What is claimed is:

1. A system comprising:

headphones comprising a pair of first and second wireless earphones to be worn simultaneously by a user, wherein the first and second earphones are separate such that when the headphones are worn by the user, the first and second earphones are not physically connected, wherein each of the first and second earphones comprises:

- a body portion that comprises:
  - a wireless communication circuit for receiving and transmitting wireless signals;
  - a processor circuit in communication with the wireless communication circuit; and
  - an ear canal portion that is inserted into an ear of the user when worn by the user; and
  - at least one acoustic transducer connected to the processor circuit; and
- an elongated portion that extends away from the body portion such that the elongated portion extends downwardly when the ear canal portion is inserted in the ear of the user;
- a microphone connected to the processor circuit and for picking up utterances of a user of the headphones;
- an antenna connected to the wireless communication circuit; and
- a rechargeable power source; and

a mobile, digital audio player that stores digital audio content and that comprises a wireless transceiver for transmitting digital audio content to the headphones via Bluetooth wireless communication links, such that each earphone receives and plays audio content received wirelessly via the Bluetooth wireless communication links from the mobile, digital audio player.

2. The system of claim **1**, further comprising a docking station for holding at least the first wireless earphone, wherein the docking station comprises a power cable for connecting to an external device for charging the at least the first wireless earphone when the docking station is connected to the external device via the power cable.

3. The system of claim **1**, wherein:

in a first operational mode, the pair of first and second earphones play audio content stored on the mobile, digital audio player and transmitted to the first and second earphones from the mobile, digital audio player via the Bluetooth wireless communication links; and

in a second operational mode, the pair of first and second earphones play audio content streamed from a remote network server.

4. The system of claim **1**, wherein the processor circuit of the first earphone is for, upon activation of a user control of the headphones, initiating transmission of a request to a remote network server that is remote from the mobile, digital audio player and in communication with the mobile, digital audio player via a data communication network.

5. The system of claim **4**, wherein the processor circuit of the first earphone is further for receiving a response to the request.

6. The headphones of claim **5**, wherein:

the mobile digital audio player is a first digital audio source;

the system further comprises a second digital audio player that is different from the first digital audio player; and

the headphones transition to play digital audio content received wirelessly from the second digital audio source via a second wireless communication link based on, at least in part, a signal strength for the second wireless communication link.

7. The headphones of claim **6**, wherein the processor circuits of the headphones are configured to receive firmware upgrades pushed from a remote network server.

8. The headphones of claim **6**, wherein each of the first and second earphones comprises a buffer for caching the audio content received by the earphone prior to being played by the at least one acoustic transducer of the earphone.

9. The system of claim **8**, wherein the processor circuits of the headphones are configured to receive firmware upgrades pushed from a remote network server.

10. The headphones of claim **9**, wherein the processor circuit of each of the first and second earphones comprises:

a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone; and

a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

11. The system of claim **1**, wherein:

the mobile digital audio player is a first digital audio source;

the system further comprises a second digital audio player that is different from the first digital audio player; and

the headphones transition to play digital audio content received wirelessly from the second digital audio source via a second wireless communication link based on, at least in part, a signal strength for the second wireless communication link.

12. The headphones of claim **11**, wherein the processor circuits of the headphones are configured to receive firmware upgrades pushed from a remote network server.

13. The headphones of claim **12**, wherein each of the first and second earphones comprises a buffer for caching the audio content received by the earphone prior to being played by the at least one acoustic transducer of the earphone.

14. The system of claim **1**, wherein the processor circuits of the headphones are configured to receive firmware upgrades pushed from a remote network server.

15. The system of claim **1**, wherein the processor circuit of the first earphone is configured to:

process audible utterances by the user picked by the microphone in response to activation of the microphone by the user; and

transmit a communication based on the audible utterances via the Bluetooth wireless communication links.

16. The system of claim **1**, wherein the rechargeable power source comprises a wirelessly chargeable circuit component.

17. The system of claim **1**, wherein the rechargeable power source comprises a passive, wireless rechargeable power source.

18. The system of claim **1**, wherein each of the first and second earphones comprises a buffer for caching the audio content received by the earphone prior to being played by the at least one acoustic transducer of the earphone.

19. The headphones of claim **1**, wherein the processor circuit of each of the first and second earphones comprises a digital signal processor that provides a sound quality enhancement for the audio content played by the at least one acoustic transducers of the earphone.

20. The headphones of claim **19**, wherein the processor circuit of each of the first and second earphones further comprises a baseband processor circuit that is in communication with the wireless communication circuit of the earphone.

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U.S. DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

September 15, 2022
(Date)

THIS IS TO CERTIFY that the attached document is a list of the papers that comprise the record before the Patent Trial and Appeal Board (PTAB) for the *Inter Partes Review* proceeding identified below.

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

Case: IPR2021-00305
Patent No. 10,506,325 B1

By authority of the

DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

Macia L. Fletcher

Certifying Officer

Prosecution History ~ IPR2021-00305

Date	Document
12/15/2020	Petition for Inter Partes Review
12/15/2020	Petitioner's Power of Attorney
12/23/2020	Notice of Filing Date Accorded to Petition
12/23/2020	Patent Owner's Mandatory Notice
12/23/2020	Patent Owner's Power of Attorney
1/12/2021	Patent Owner's Updated Mandatory Notices
2/25/2021	Patent Owner's Second Updated Mandatory Notice
3/15/2021	Patent Owner's Updated Mandatory Notices
3/23/2021	Patent Owner's Preliminary Response
3/25/2021	Patent Owner's Updated Mandatory Notices
4/9/2021	Patent Owner's Updated Mandatory Notices
4/13/2021	Petitioner's Reply to Patent Owner's Preliminary Response
4/20/2021	Patent Owner's Sur-Reply in Support of Its Preliminary Response
6/3/2021	Decision - Institution of Inter Partes Review
6/3/2021	Scheduling Order
6/16/2021	Joint Report Detailing Significant Developments in Parallel District Court Litigations
7/7/2021	Notice of Deposition - Cooperstock
7/27/2021	Petitioner's Updated Mandatory Notices
7/27/2021	Petitioner's Power of Attorney
8/27/2021	Patent Owner's Response
9/1/2021	Order - Conduct of the Proceedings
10/21/2021	Order - Conduct of the Proceedings
11/2/2021	Motion for Pro Hac Vice Admission - Sproul
11/9/2021	Notice of Stipulation of Changes to Due Dates 2 & 3
11/17/2021	Petitioner's Updated List of Exhibits
11/18/2021	Order - Pro Hac Vice Admission - Sproul
12/1/2021	Notice of Deposition - McAlexander
12/3/2021	Petitioner's Updated Mandatory Notice
12/3/2021	Petitioner's Power of Attorney
12/10/2021	Patent Owner's Updated Mandatory Notice
12/10/2021	Motion for Pro Hac Vice Admission - Pieja
12/14/2021	Order - Pro Hac Vice Admission - Pieja
12/21/2021	Petitioner's Updated Mandatory Notice
12/21/2021	Petitioner's Power of Attorney
12/23/2021	Petitioner's Reply to Patent Owner's Response
1/10/2022	Notice of Deposition - Cooperstock
1/10/2022	Notice of Stipulation of Changes to Due Date 3
1/13/2022	Petitioner's Updated Mandatory Notices
1/21/2022	Petitioner's Request for Oral Hearing
1/24/2022	Patent Owner's Request for Oral Argument
1/25/2022	Order - Setting Oral Argument
2/8/2022	Patent Owner's Sur-Reply

Prosecution History ~ IPR2021-00305

Date	Document
2/28/2022	Patent Owner's Updated Exhibit List
2/28/2022	Patent Owner's Updated Mandatory Notice
3/1/2022	Petitioner's Updated Exhibit List
3/18/2022	Oral Hearing Transcript
5/31/2022	Final Written Decision

U.S. DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

September 15, 2022
(Date)

THIS IS TO CERTIFY that the attached document is a list of the papers that comprise the record before the Patent Trial and Appeal Board (PTAB) for the *Inter Partes Review* proceeding identified below.

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

Case: IPR2021-00381
Patent No. 10,491,982 B1

By authority of the

DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

Macia L. Fletcher

Certifying Officer

Prosecution History ~ IPR2021-00381

Date	Document
1/4/2021	Petition for Inter Partes Review
1/4/2021	Petitioner's Power of Attorney
1/13/2021	Patent Owner's Power of Attorney
1/13/2021	Patent Owner's Mandatory Notice
1/21/2021	Notice of Filing Date Accorded to Petition
2/24/2021	Patent Owner's Updated Mandatory Notice
3/15/2021	Patent Owner's Updated Mandatory Notices
3/25/2021	Patent Owner's Updated Mandatory Notices
4/9/2021	Patent Owner's Updated Mandatory Notices
4/21/2021	Patent Owner's Preliminary Response
5/7/2021	Petitioner's Reply to Patent Owner's Preliminary Response
5/17/2021	Patent Owner's Sur-Reply in Support of Its Preliminary Response
6/23/2021	Patent Owner's Updated Mandatory Notice
6/24/2021	Patent Owner's Updated Exhibit List
7/2/2021	Decision - Institution of Inter Partes Review
7/2/2021	Scheduling Order
8/19/2021	Notice of Deposition - Cooperstock
9/1/2021	Order - Conduct of the Proceedings
9/28/2021	Patent Owner's Response
11/2/2021	Motion for Pro Hac Vice Admission - Sproul
11/17/2021	Petitioner's Updated List of Exhibits
11/18/2021	Order - Pro Hac Vice Admission - Sproul
12/1/2021	Notice of Deposition - McAlexander
12/3/2021	Petitioner's Updated Mandatory Notice
12/3/2021	Petitioner's Power of Attorney
12/10/2021	Patent Owner's Updated Mandatory Notice
12/10/2021	Motion for Pro Hac Vice Admission - Pieja
12/14/2021	Order - Pro Hac Vice Admission - Pieja
12/21/2021	Petitioner's Updated Mandatory Notice
12/21/2021	Petitioner's Power of Attorney
12/21/2021	Petitioner's Reply to Patent Owner's Response
1/10/2022	Notice of Deposition - Cooperstock
1/10/2022	Notice of Stipulation of Changes to Due Date 3
2/8/2022	Patent Owner's Sur-Reply
2/22/2022	Petitioner's Request for Oral Hearing
2/22/2022	Petitioner's Updated Mandatory Notices
2/22/2022	Patent Owner's Request for Oral Argument
2/28/2022	Patent Owner's Updated Mandatory Notice
2/28/2022	Order - Setting Oral Argument
3/31/2022	Petitioner's Updated Exhibit List
3/31/2022	Patent Owner's Updated Exhibit List
5/19/2022	Oral Hearing Transcript

Prosecution History ~ IPR2021-00381

Date	Document
6/27/2022	Final Written Decision

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss, et al.		
U.S. Patent No.:	10,506,325	Attorney Docket No.:	50095-0022IP1
Issue Date:	December 10, 2019		
Appl. Serial No.:	16/528,703		
Filing Date:	August 1, 2019		
Title:	SYSTEM WITH WIRELESS EARPHONES		

Mail Stop Patent Board
Patent Trial and Appeal Board
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT NO. 10,506,325 PURSUANT TO 35 U.S.C. §§311–319, 37 C.F.R. §42

Apple, Inc. ("Petitioner" or "Apple") petitions for *Inter Partes* Review ("IPR") of claims 1-4, 9, 10, and 14-18 ("the Challenged Claims") of U.S. Patent No. 10,506,325 ("the '325 patent").

I. REQUIREMENTS FOR IPR UNDER 37 C.F.R. §42.104

A. Grounds for Standing Under 37 C.F.R. §42.104(a)

Apple certifies that the '325 patent is available for IPR. This petition is being filed within one year of service of a complaint against Apple. Apple is not barred or estopped from requesting this review.

B. Challenge Under 37 C.F.R. §42.104(b) and Relief Requested

Apple requests an IPR on the grounds below. Additional explanation and support for each ground is set forth in the expert declaration of Dr. Cooperstock, referenced throughout this petition.

Ground	Claims	Basis (§103)
1A	1, 2, 16-18	Rosener, Huddart
1B	3, 4	Rosener, Huddart, Haupt
1C	9, 10, 14	Rosener, Huddart, Price
1D	15	Rosener, Huddart, Paulson
1E	16, 17	Rosener, Huddart, Vanderelli

The '325 patent was filed 8/1/2019, and claims priority to 4/7/2008.

1. Rosener-Huddart Combination

As explained above, Rosener describes wireless systems in which audio data sinks (e.g., earphones) can wirelessly communicate with external audio devices. APPLE-1004, ¶¶[0011], [0030]. The wireless systems include wireless earphones (e.g., earbuds, canalphones) that address drawbacks of prior art systems. *Id.* For example, Rosener discusses how "conventional wired binaural headsets" require use of a "headband and/or electrical connection (i.e., electrical wiring) between the two headphones," which can be uncomfortable and disruptive. APPLE-1004, ¶[0010]. Likewise, while Rosener recognizes that an "over-the-ear wireless headset" avoids the need for a headband or cabling, this type of device is "monaural" and consequently "incapable of providing high-quality stereo sound to a user." *Id.*, ¶[0010]. To address these drawbacks, Rosener describes techniques for implementing wireless earphones that are "physically and electrically-separated data sinks" and that are also capable of providing high-quality stereo sound. *Id.*, [0011]; APPLE-1003, ¶47.

Yet, while Rosener is principally focused on implementing wireless earphones that provide stereo sound while being physically and electrically separated, its disclosure does not explicitly address other aspects of wireless earphones. For example, while Rosener describes earphones as including batteries for power delivery, its disclosure is not focused on rechargeable batteries or the use

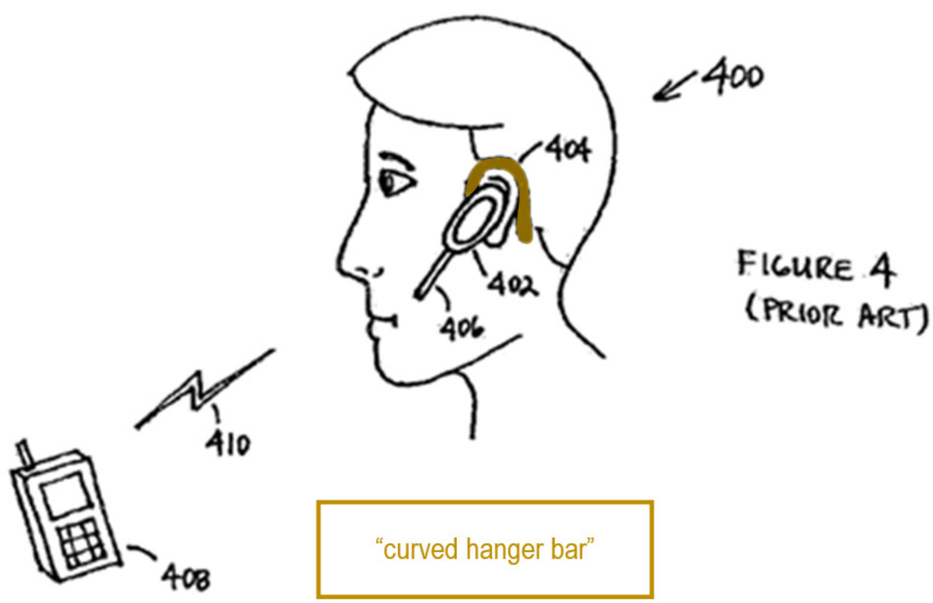
of charging devices. A POSITA would have understood, however, that Rosener's earphones could have incorporated rechargeable batteries since this configuration was conventional around the time of its disclosure, as demonstrated by Huddart. APPLE-1003, ¶48. Huddart describes "a battery and charger circuit for charging both the headset battery and wireless earbud battery when inserted into the pocket charger/carrier." APPLE-1005, 8:25-34. Given this disclosure, a POSITA would have understood that each of Rosener's earphones could be similarly configured to incorporate rechargeable batteries. APPLE-1003, ¶48.

To the extent that Rosener is deemed to lack disclosure of rechargeable batteries, a POSITA would have found it obvious to incorporate rechargeable batteries into Rosener's earphones based on the teachings of Huddart. APPLE-1003, ¶49. For instance, the combination would have addressed limitations associated with using non-rechargeable batteries, by eliminating or reducing the need to periodically replace the batteries, thereby removing or reducing the cost of doing so and also improving user convenience. *Id*.

A POSITA would have also understood that rechargeable batteries would have been advantageous specifically in earphones with earbud-type form factors. APPLE-1003, ¶50. Huddart, for example, recognizes that an earbud has "a relatively smaller capacity battery due to its limited size" and therefore would benefit particularly from being rechargeable, to avoid needing to frequently replace

clip, **earloop**, or other suitable securing mechanism to help maintain the earphone 502, 504 on the ear of the user." APPLE-1004, ¶[0030] (emphasis added). A POSITA would have understood from this description that Rosener's disclosure includes embodiments in which the housing of each of earphones 502, 504 is connected to an earloop ("***curved hanger bar***") to improve the manner in which each of the earphones is secured to the user's ear. APPLE-1003, ¶82.

Rosener also acknowledges that use of an earloop as a securing mechanism was well-known in the prior art as of its filing date of August 7, 2006, which predates the Critical Date. APPLE-1004, ¶¶[0008]-[0010]; APPLE-1003, ¶83. For example, Figure 4 shows a headphone 402 with an earloop 404 (gold).



APPLE-1004, Figure 4 (annotated)

Rosener discloses that earloop 404 is "configured to fit around the outer ear

of the user 400." APPLE-1004, ¶[0008]. And, as shown above in Figure 4, an earloop (as known in the art and as disclosed for use with earphones 502, 504) includes a curved portion that wraps around the outer ear, and "***rests upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user***." Below is a modified version of Figure 5 showing a configuration of earphones 502, 504 including the earloops disclosed in Rosener, as discussed above. APPLE-1003, ¶84.

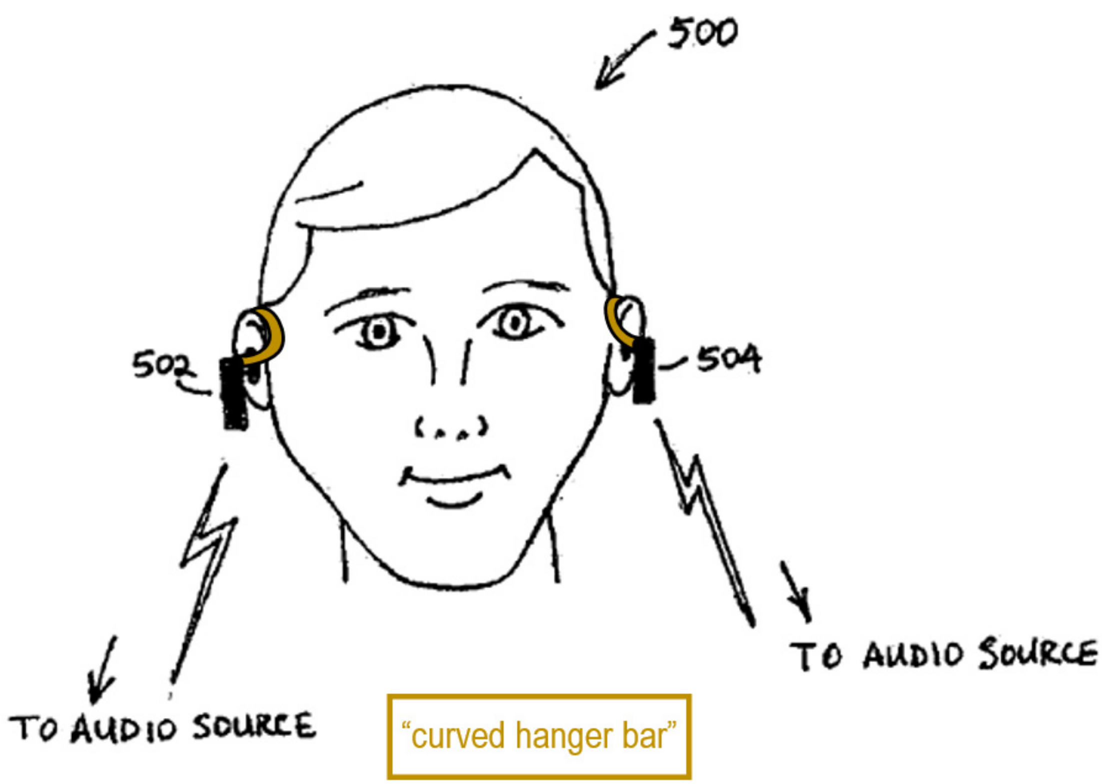


FIGURE 5

APPLE-1004, Figure 5 (annotated/modified to include earloop 404 of Figure 4)

Rosener's disclosure of "earloop[s]" to "help maintain the earphone 502, 504 on the ear of the user" thus teaches a system in which each of the elongated portions of the housings of earphones 502, 504 are connected to an earloop providing the same type of securing mechanism as shown for earloop 402. APPLE-1004, ¶[0030]. Rosener discloses this configuration given its teaching that each of earphones 502, 504 can include earloops and acknowledgement that use of earloops was conventional. *Id.*, ¶¶[0008], [0030]; APPLE-1003, ¶85.

[1.7] a wireless communication circuit for receiving and transmitting wireless signals;

Rosener discloses that each of earphones 502, 504 includes an RF transceiver circuit ("***wireless communication circuit***"). APPLE-1004, ¶¶[0011], [0030]. A POSITA would have recognized that a transceiver circuit, by definition, is "***for receiving and transmitting wireless signals***." APPLE-1003, ¶86. Indeed, Rosener expressly identifies this function of transceiver circuitry by noting that "RF transceivers containing both an RF transmitter and an RF receiver may be used in place of" separate RF transmitters and RF receivers. APPLE-1004, ¶[0049]. Figure 9 shows the circuit components of a "transceiver 900." As shown in the following annotated figure, the circuit including RF transmitter portion 902, RF receiver portion 904, duplexer 908, A/D converter 910, and D/A converter 912 is "***a wireless communication circuit for receiving and transmitting wireless***

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00305
U.S. PATENT NO. 10,506,325

PATENT OWNER'S UPDATED MANDATORY NOTICES

Patent Owner, Koss Corporation, submits the following updates to its Mandatory Notices.

I. REAL PARTY-IN-INTEREST

No change.

II. RELATED MATTERS

U.S. Patent No. 10,506,325 ("the '325 Patent") is currently involved in the following lawsuits: Koss Corporation v. PEAG LLC d/b/a JLab Audio, Case No. 6:20-cv-00662 (W.D. Tex.); Koss Corporation v. Plantronics, Inc. et al., Case No. 6:20-cv-00663 (W.D. Tex.); Koss Corporation v. Skullcandy, Inc., Case No. 6:20-cv-00664 (W.D. Tex); Koss Corporation v. Apple Inc., Case No. 6-20-cv-00665; and Apple Inc. v. Koss Corporation, Case No. 4:20-cv-05504 (N.D. Cal.)**; and Koss Corporation v. Skullcandy, Inc., Case No. 2:21-cv-00203 (D. Utah).**

The '325 Patent is also involved in the following *inter partes* review: *Apple Inc. v . Koss Corporation*, IPR2021-00679, filed March 22, 2021.

The '325 Patent claims priority to PCT application No. PCT/US2009/039754, filed April 7, 2009 (the "PCT Application") and provisional application Serial No. 61/123,265 filed April 8, 2008 (the "Provisional Application"). IPR2021-00297, filed December 7, 2020, is for a patent (Patent 10,368,155) that also claims priority to the PCT Application and the Provisional Application. Additionally, IPR2021-00381, filed January 4, 2021, is for a patent (Patent 10,491,982) that also claims

Trials@uspto.gov
571-272-7822

Paper 14
Entered: June 3, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS COPRORATION,
Patent Owner.

IPR2021-00305
Patent 10,506,325 B1

Before DAVID C. MCKONE, GREGG I. ANDERSON,
and NORMAN H. BEAMER, *Administrative Patent Judges*.

MCKONE, Administrative Patent Judge.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition (Paper 2, "Pet.") requesting *inter partes* review of claims 1–4, 9, 10, and 14–18 of U.S. Patent No. 10,506,325 B1 (Ex. 1001, "the '325 patent"). Pet. 1. Koss Corporation ("Patent Owner") filed a Preliminary Response (Paper 9, "Prelim. Resp."). Pursuant to our authorization, Petitioner filed a Reply (Paper 12) and Patent Owner filed a Sur-Reply (Paper 13).

We have authority to determine whether to institute an *inter partes* review. *See* 35 U.S.C. § 314 (2016); 37 C.F.R. § 42.4(a) (2020). The standard for instituting an *inter partes* review is set forth in 35 U.S.C. § 314(a), which provides that an *inter partes* review may not be instituted "unless . . . there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." For the reasons explained below, we institute an *inter partes* review of the '325 patent.

B. Related Matters

1. Lawsuits

Petitioner advises us that it is a defendant in a case filed by Patent Owner asserting the '325 patent in the United States District Court for the Western District of Texas ("Texas court") captioned *Koss Corporation v. Apple Inc.*, Case No. 6:20-cv-00665 (W.D. Tex.) ("Texas case"). Pet. 79; *see also* Paper 11, 1. Patent Owner identifies another three lawsuits where Patent Owner is plaintiff and the '325 patent is asserted against other parties. Paper 11, 1. Patent Owner identifies two other cases involving the '325 patent, including one filed by Petitioner in the United States District Court

E. The Asserted Grounds

Petitioner asserts the following grounds of unpatentability (Pet. 1–2):

Reference(s)	Basis	Claims Challenged
Rosener, Huddart	§ 103(a)	1, 2, 16–18
Rosener, Huddart, Haupt	§ 103(a)	3, 4
Rosener, Huddart, Price	§ 103(a)	9, 10, 14
Rosener, Huddart, Paulson	§ 103(a)	15
Rosener, Huddart, Vanderelli	§ 103(a)	16, 17

II. ANALYSIS

A. Patent Owner's Argument under 35 U.S.C. § 314(a) Based on Parallel Proceeding

Institution of *inter partes* review is discretionary. *See Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1367 (Fed. Cir. 2016) ("[T]he PTO is permitted, but never compelled, to institute an IPR proceeding."); 35 U.S.C. § 314(a). In the Preliminary Response, Patent Owner contends that we should exercise our discretion to deny the Petition because Petitioner's invalidity grounds will be resolved in the Texas case before our deadline for a final written decision. Prelim. Resp. 5–20.

The Board has held that the advanced state of a parallel district court action is a factor that may weigh in favor of denying a petition under § 314(a). *See NHK Spring Co. v. Intri-Plex Techs., Inc.*, IPR2018-00752, Paper 8 at 20 (PTAB Sept. 12, 2018) (precedential); Patent Trial and Appeal Board, Consolidated Trial Practice Guide, 58 & n.2 (Nov. 2019) ("Trial Practice Guide"), available at https://www.uspto.gov/sites/default/files/documents/tpgnov.pdf. We consider the following factors to assess

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
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CASE: IPR2021-00305
U.S. PATENT NO. 10,506,325

PATENT OWNER'S NOTICE OF APPEAL

To the Director of the United States Patent and Trademark Office:

Notice is hereby given, pursuant to 37 C.F.R. § 90.2(a), that Patent Owner Koss Corporation ("Koss") appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered on May 31, 2022, (Paper 47) ("Final Written Decision") by the Patent Trial and Appeal Board ("the Board"), and from all underlying orders, decisions, rulings, and opinions. A copy of the Final Written Decision is attached as Exhibit A.

In accordance with 37 C.F.R. § 90.2(a)(3)(ii), Koss indicates that the issues on appeal include, but are not limited to, the Board's determination that claims 1-4, 9, 10, and 14-17 (the "Invalidated Claims") of U.S. Patent 10,506,325 B1 ("'325 Patent") are unpatentable over the prior art of record, and any finding or determinations supporting or related to that ruling including, without limitation, the Board's decision that Petitioner showed by a preponderance of the evidence that the Invalidated Claims of the '325 Patent are obvious over the prior art of record and that the Patent Owner failed to show that the commercial success of a certain commercial product, the Powerbeats Pro wireless earphones, is a secondary indicia of the nonobviousness of the Invalidated Claims.

Pursuant to 37 C.F.R. § 90.3(a)(1), Patent Owner is timely filing this Notice of Appeal within sixty-three (63) days of the Board's May 31, 2022 Final Written Decision. Pursuant to 37 C.F.R. § 90.2(a)(1), Patent Owner is filing copies of this

Notice of Appeal with the Director of the United States Patent and Trademark Office and with the Board. Pursuant to Federal Circuit Rule 15(a)(1), Patent Owner is filing a copy of this Notice of Appeal with the Clerk of the United States Court of Appeals for the Federal Circuit, and paying the required fees.

Respectfully submitted this 1st day of August, 2022.

K&L Gates, LLP

By: /Mark G. Knedeisen/
Mark G. Knedeisen
Reg. No. 42,747

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss		
U.S. Patent No.:	10,506,325	Attorney Docket No.:	50095-0022IP1
Issue Date:	December 10, 2019		
Appl. Serial No.:	16/528,703		
Filing Date:	August 1, 2019		
Title:	SYSTEM WITH WIRELESS EARPHONES		

DECLARATION OF DR. JEREMY COOPERSTOCK

II. QUALIFICATIONS

6. I am a professor in the Department of Electrical and Computer Engineering at McGill University. My curriculum vitae is provided as Appendix A.

7. I received my B.Sc. in Electrical Engineering from the University of British Columbia, my M.Sc. in Computer Science from the University of Toronto in 1992, and my Ph.D. in Electrical and Computer Engineering from the University of Toronto in 1996.

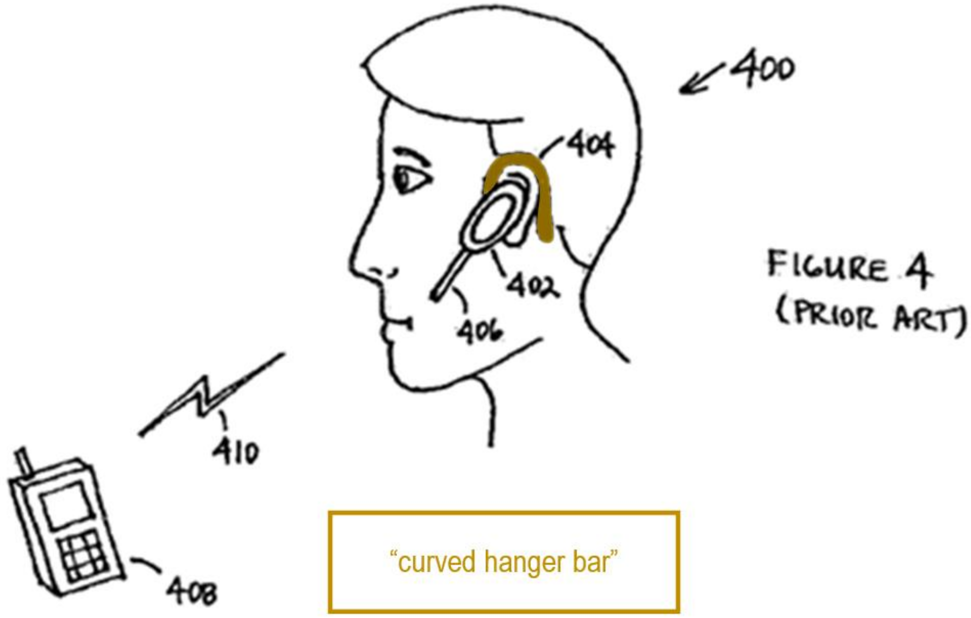
8. I am a member of the Centre for Intelligent Machines, and a founding member of the Centre for Interdisciplinary Research in Music Media and Technology at McGill University. I also direct the Shared Reality Lab at McGill, which focuses on computer mediation to facilitate high-fidelity human communication and the synthesis of perceptually engaging, multimodal, immersive environments. I led the development of the Intelligent Classroom, the world's first Internet streaming demonstrations of Dolby Digital 5.1, multiple simultaneous streams of uncompressed high-definition video, a high-fidelity orchestra rehearsal simulator, a simulation environment that renders graphic, audio, and vibrotactile effects in response to footsteps, and a mobile game treatment for amblyopia.

9. My work on the Ultra-Videoconferencing system was recognized by an award for Most Innovative Use of New Technology from ACM/IEEE

D. Person of Ordinary Skill in the Art

34. Based upon my experience in this area and taking into account the above references, a person of ordinary skill in the art at the time of the ’325 patent’s Critical Date (“POSITA”) would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks. Superior education could compensate for a deficiency in work experience, and vice-versa.

35. I base this characterization of a POSITA in view of my professional, academic, and personal experiences, including my knowledge of colleagues and others at the time of the invention of the ’325 patent on or shortly before the Critical Date. Specifically, my experience working with industry, undergraduate and post-graduate students, colleagues from academia, and designers and engineers practicing in industry has allowed me to become directly and personally familiar with the level of skill of individuals and the general state of the art. I am familiar with the knowledge of persons of ordinary skill in the art as of the Critical Date.



APPLE-1004, Figure 4 (annotated)

84. Rosener describes that earloop 404 is "configured to fit around the outer ear of the user 400." APPLE-1004, ¶[0008]. And, as shown above in Figure 4, earloop (as known in the art and as disclosed for use with earphones 502, 504) includes a curved portion that wraps around the outer ear, and "***rest[s] upon an upper external curvature of an ear of the user behind an upper portion of an auricula of the ear of the user***." Below is a modified version of Figure 5 showing a configuration of earphones 502, 504 including earloops, as discussed above.

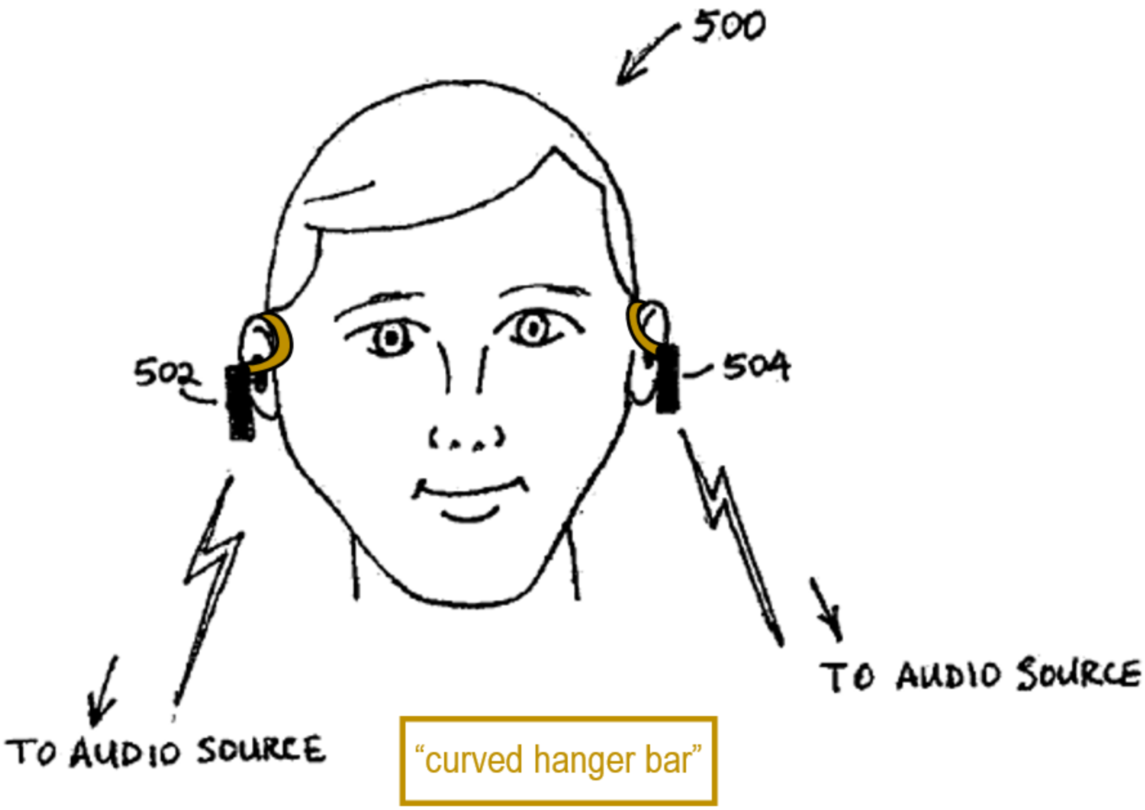


FIGURE 5

APPLE-1004, Figure 5 (annotated/modified to include Figure 4's earloop 404)

85. Rosener's disclosure of "earloop[s]" to "help maintain the earphone 502, 504 on the ear of the user" teaches a system in which each of the elongated portions of the housings of earphones 502, 504 are connected to an earloop that provides the same type of securing mechanism as shown for earloop 402. APPLE-1004, ¶[0030]. Rosener discloses this configuration given its teaching that each of

US 20080076489A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2008/0076489 A1
Rosener et al. (43) Pub. Date: Mar. 27, 2008

(54) PHYSICALLY AND ELECTRICALLY-SEPARATED, DATA-SYNCHRONIZED DATA SINKS FOR WIRELESS SYSTEMS

(75) Inventors: **Douglas K. Rosener**, Santa Cruz, CA (US); **Jay Wilson**, Portola Valley, CA (US); **Scott Walsh**, Foxham (GB); **David Huddart**, Westbury-on-Trym (GB); **Andrew Knowles**, Southampton (GB)

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SANTA CRUZ, CA 95060-0635

(73) Assignee: **PLANTRONICS, INC.**

(21) Appl. No.: **11/500,571**

(22) Filed: **Aug. 7, 2006**

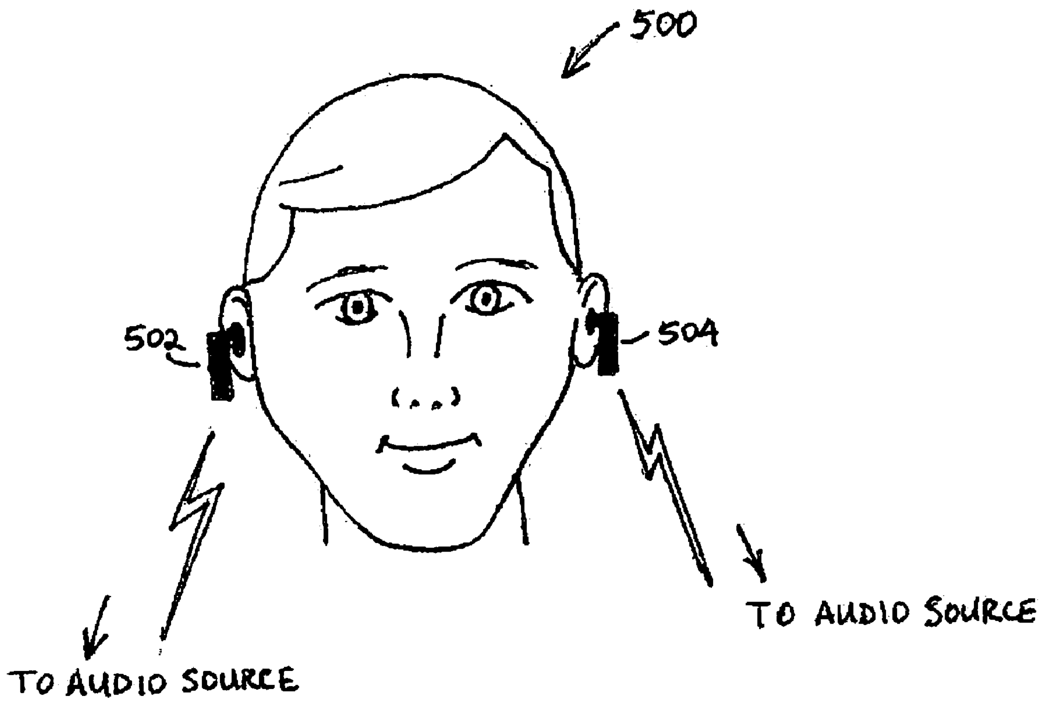
Publication Classification

(51) **Int. Cl.**
H04M 1/00 (2006.01)

(52) **U.S. Cl.** **455/575.2**

(57) **ABSTRACT**

Wireless systems having a plurality of physically and electrically-separated data sinks. An exemplary wireless system includes first and second data sinks having no physical or electrical connection therebetween. The first and second data sinks each include a wireless communication device, e.g., a radio frequency (RF) receiver or transceiver configured to receive data signals over one or more single-access wireless links or over a multi-access wireless link. The first and second data sinks in exemplary embodiments may comprise audio data sinks, e.g., stereo speakers, left-ear and right-ear earphones (e.g., earbuds or canalphones), left-ear and right-ear circum-aural over-the-ear headphones, etc. At least one of the first and second data sinks may also be coupled to a wireless transmitter and accompanying data source (e.g., a microphone or sensor), so as to provide, for example, two-way communications between a user and an external data device (e.g., a cellular telephone).



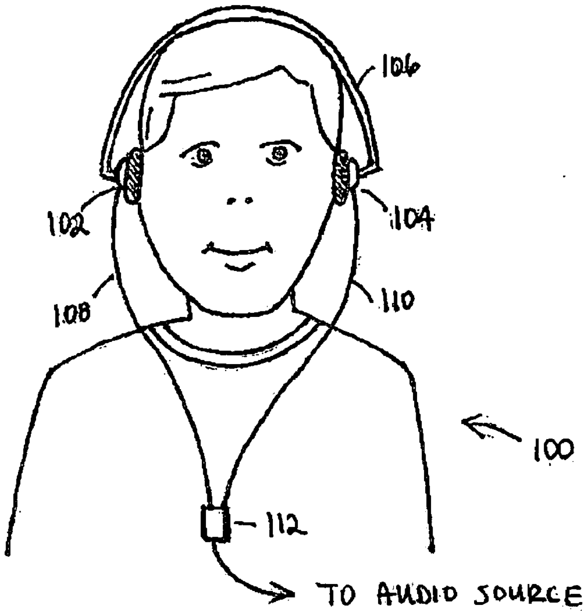


FIGURE 1A
(PRIOR ART)

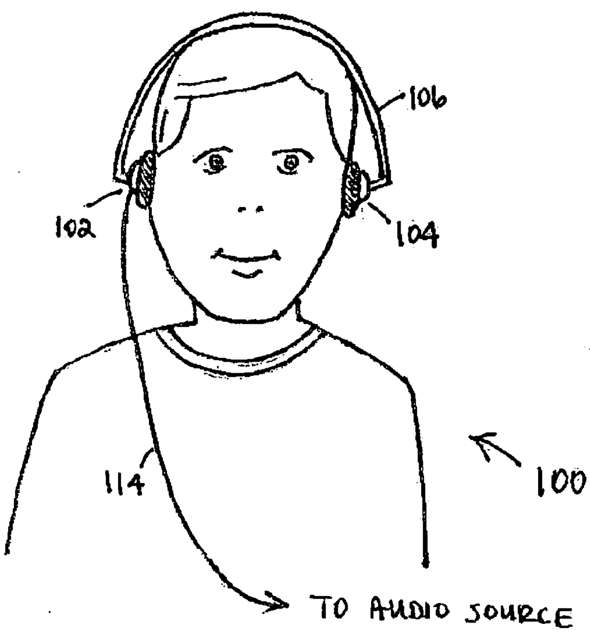


FIGURE 1B
(PRIOR ART)

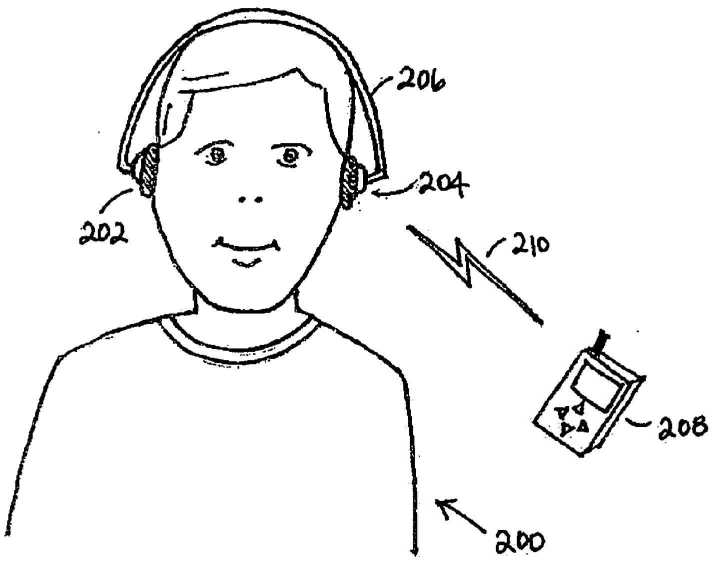


FIGURE 2
(PRIOR ART)

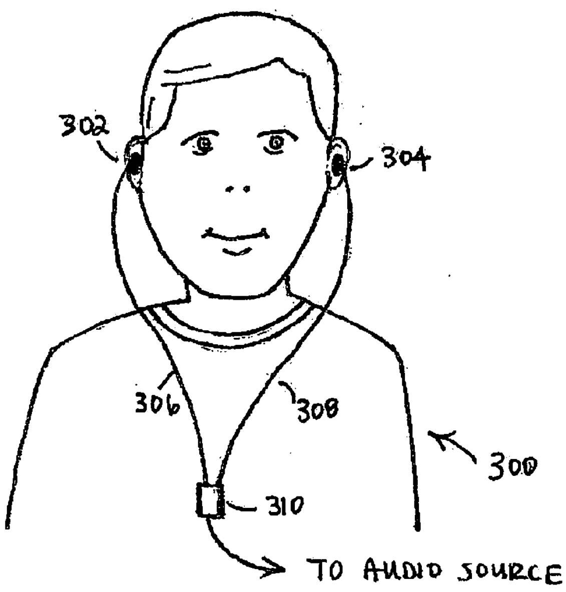


FIGURE 3
(PRIOR ART)

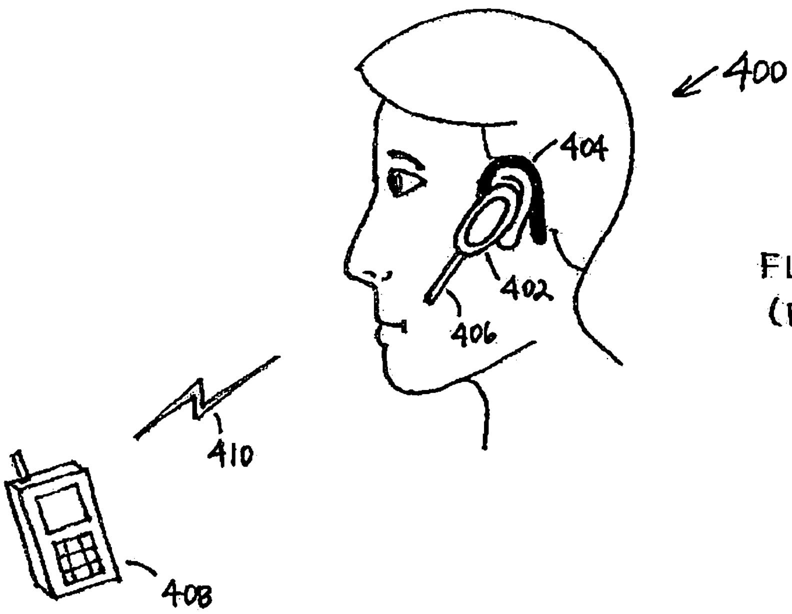


FIGURE 4
(PRIOR ART)

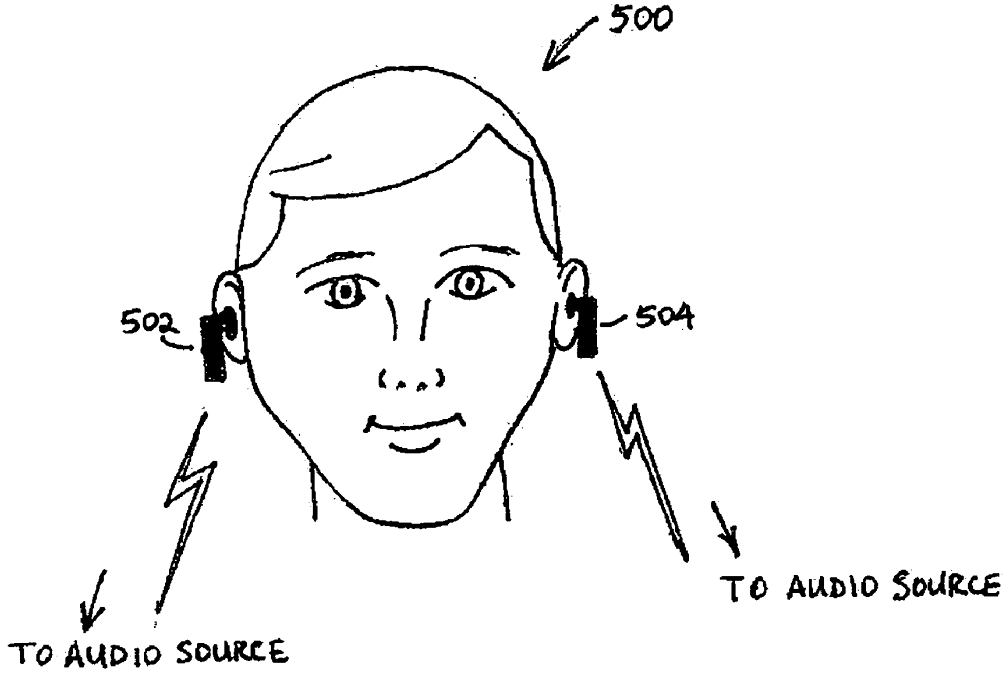


FIGURE 5

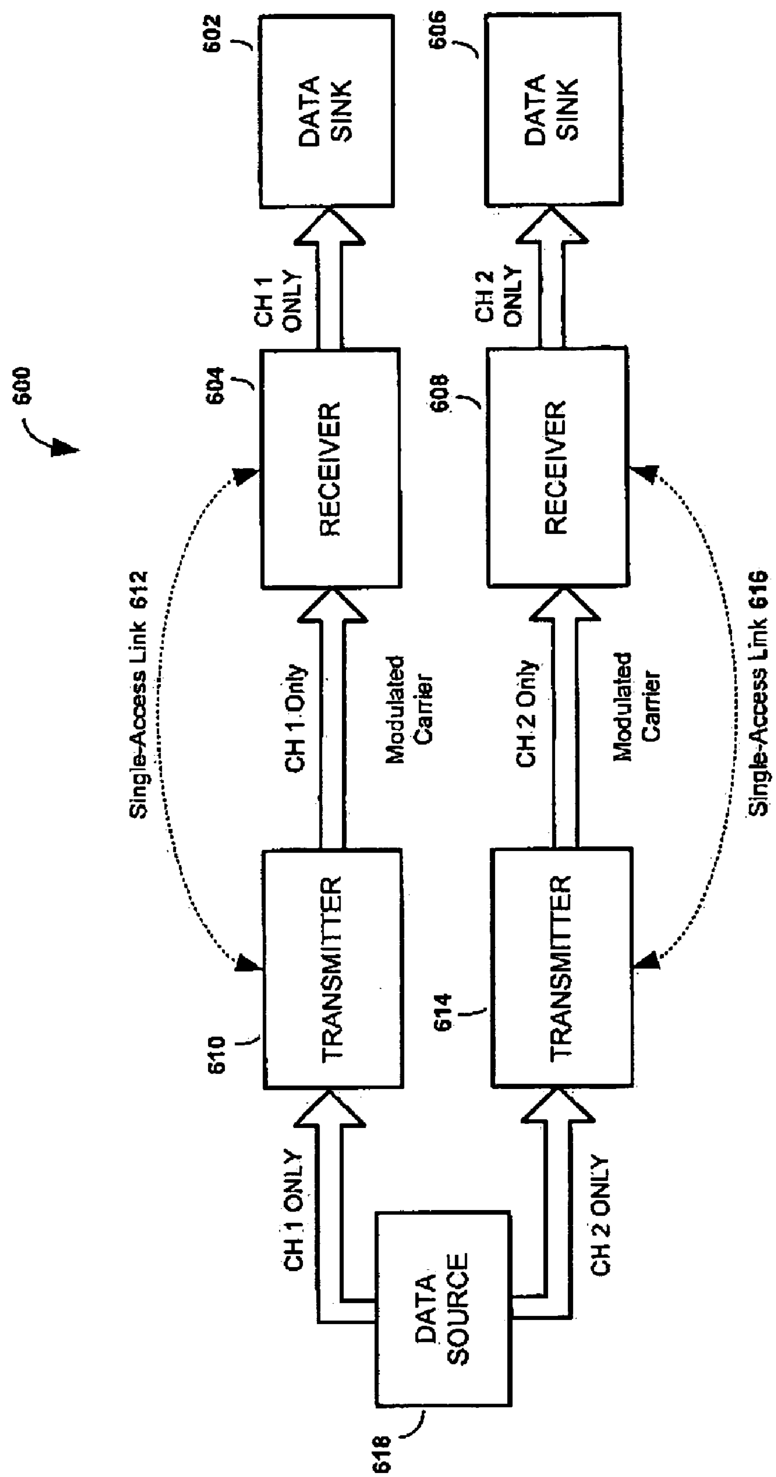

600
602
DATA SINK
606
DATA SINK
CH 1 ONLY
CH 2 ONLY
604
RECEIVER
608
RECEIVER
Single-Access Link 612
CH 1 Only
Modulated Carrier
CH 2 Only
Modulated Carrier
Single-Access Link 616
610
TRANSMITTER
614
TRANSMITTER
CH 1 ONLY
CH 2 ONLY
DATA SOURCE
618

FIGURE 6

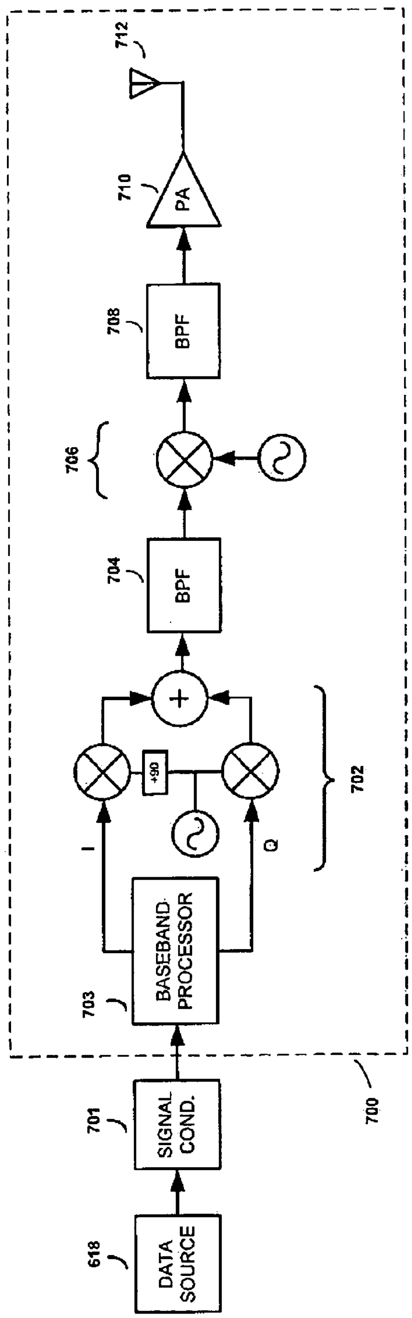


FIGURE 7A

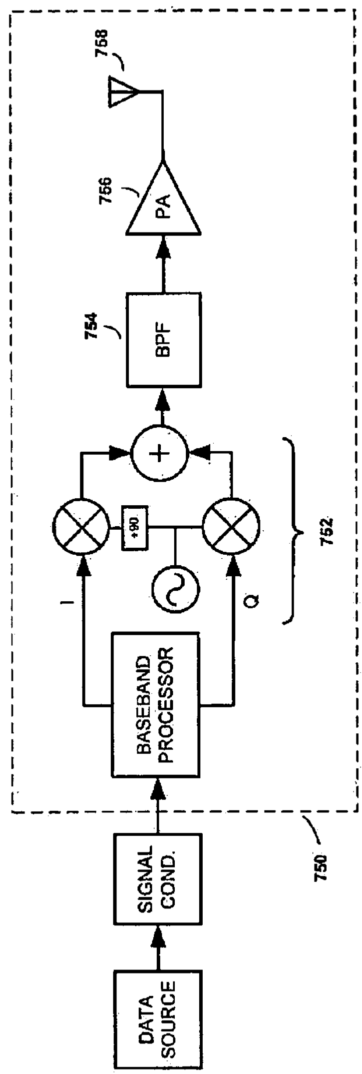


FIGURE 7B

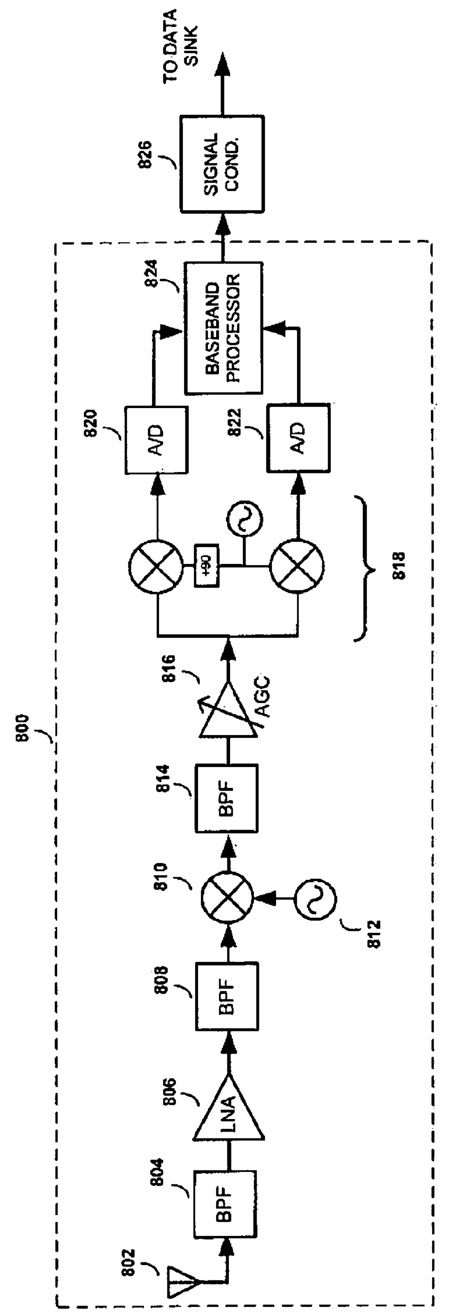


FIGURE 8A

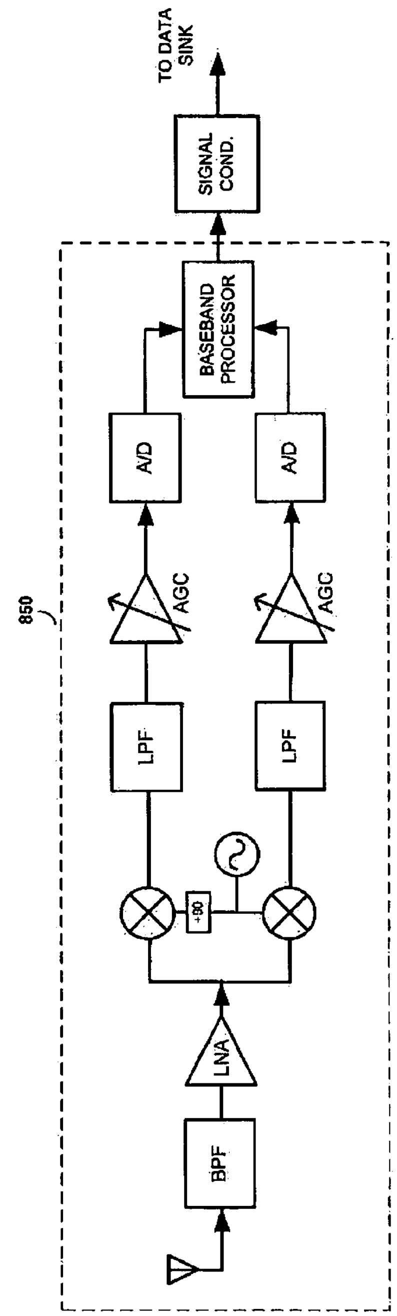


FIGURE 8B

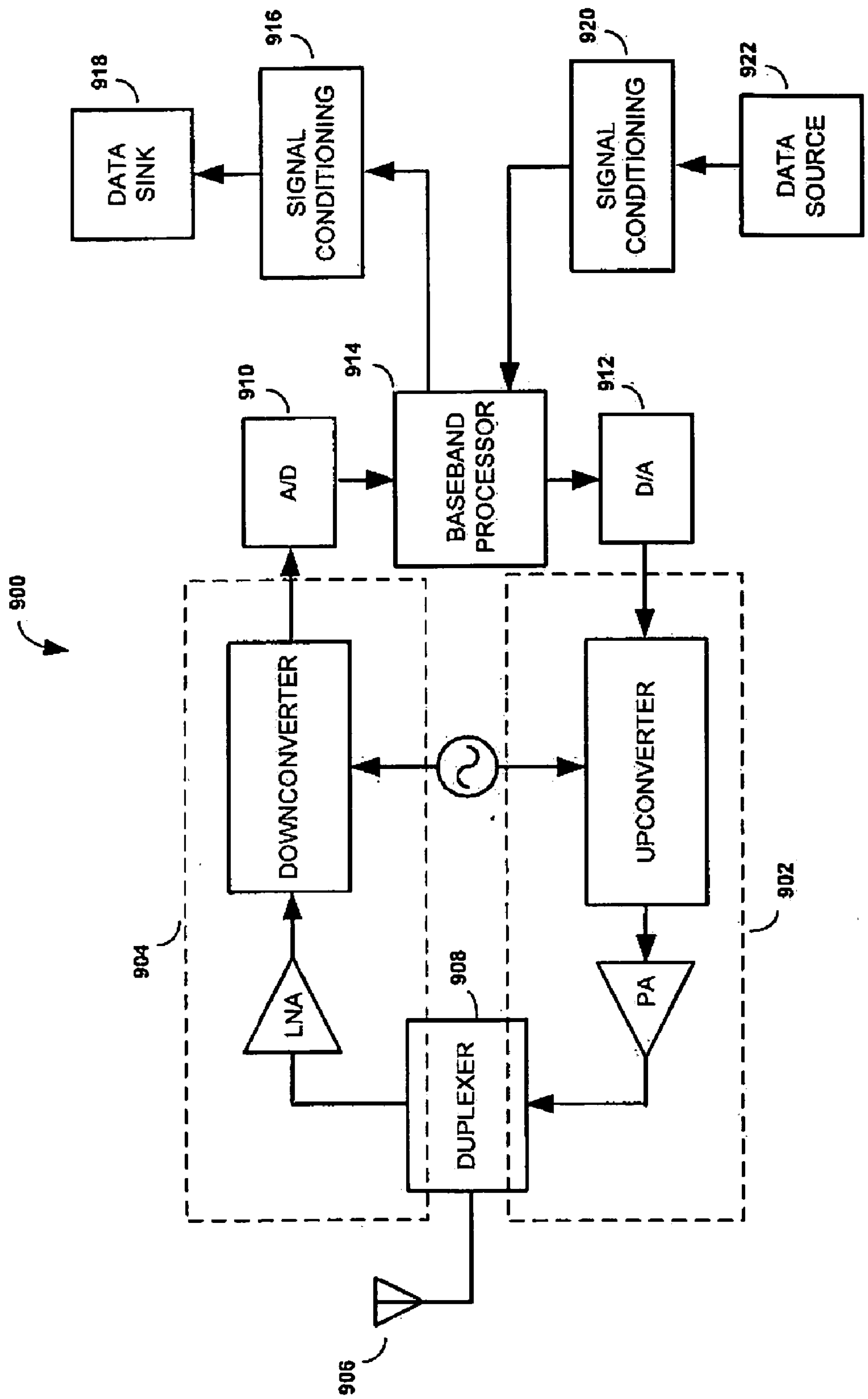

900
918
DATA SINK
916
SIGNAL CONDITIONING
920
SIGNAL CONDITIONING
922
DATA SOURCE
910
A/D
914
BASEBAND PROCESSOR
912
D/A
DOWNCONVERTER
UPCONVERTER
904
LNA
908
DUPLEXER
PA
902
906

FIGURE 9

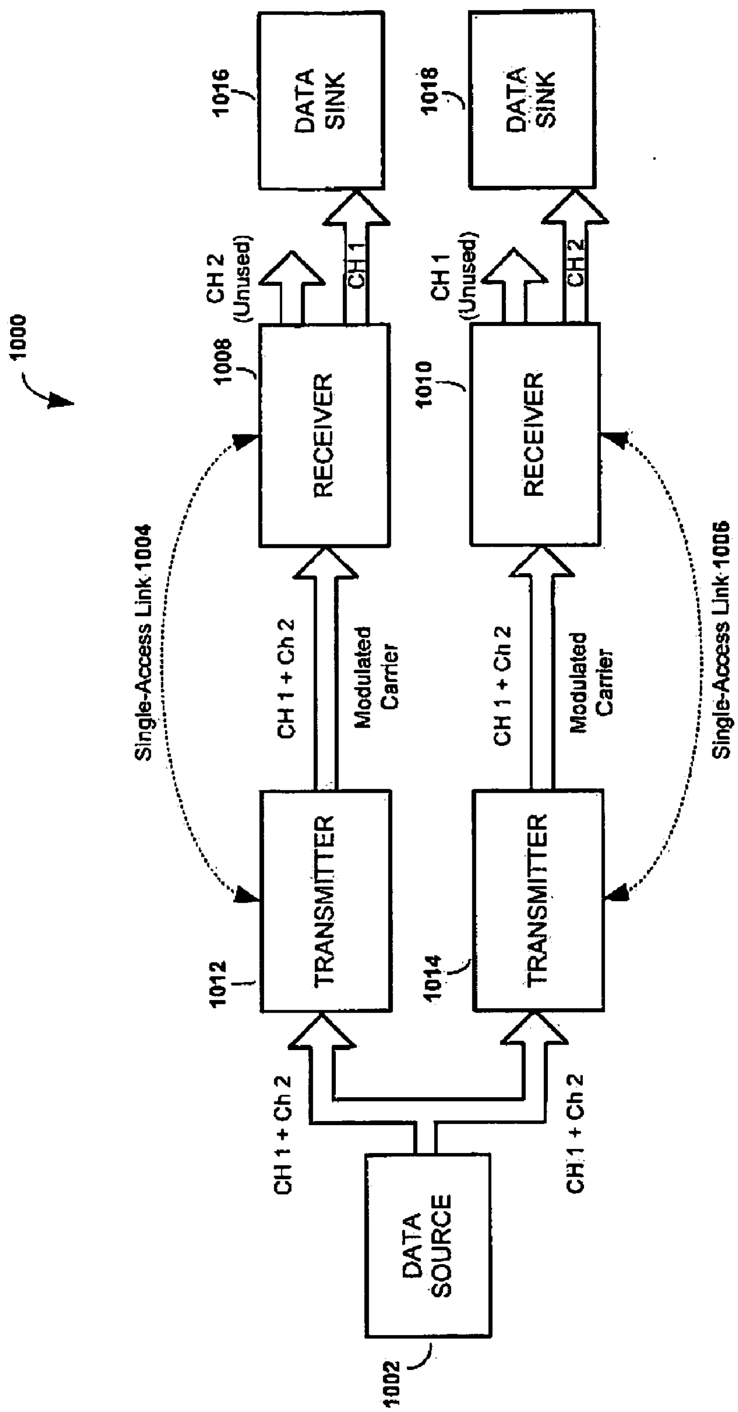

1000
DATA SOURCE
1002
CH 1 + Ch 2
CH 1 + Ch 2
TRANSMITTER
1012
TRANSMITTER
1014
CH 1 + Ch 2
Modulated Carrier
CH 1 + Ch 2
Modulated Carrier
Single-Access Link 1004
Single-Access Link 1006
RECEIVER
1008
RECEIVER
1010
CH 2 (Unused)
CH 1
CH 1 (Unused)
CH 2
DATA SINK
1016
DATA SINK
1018

FIGURE 10

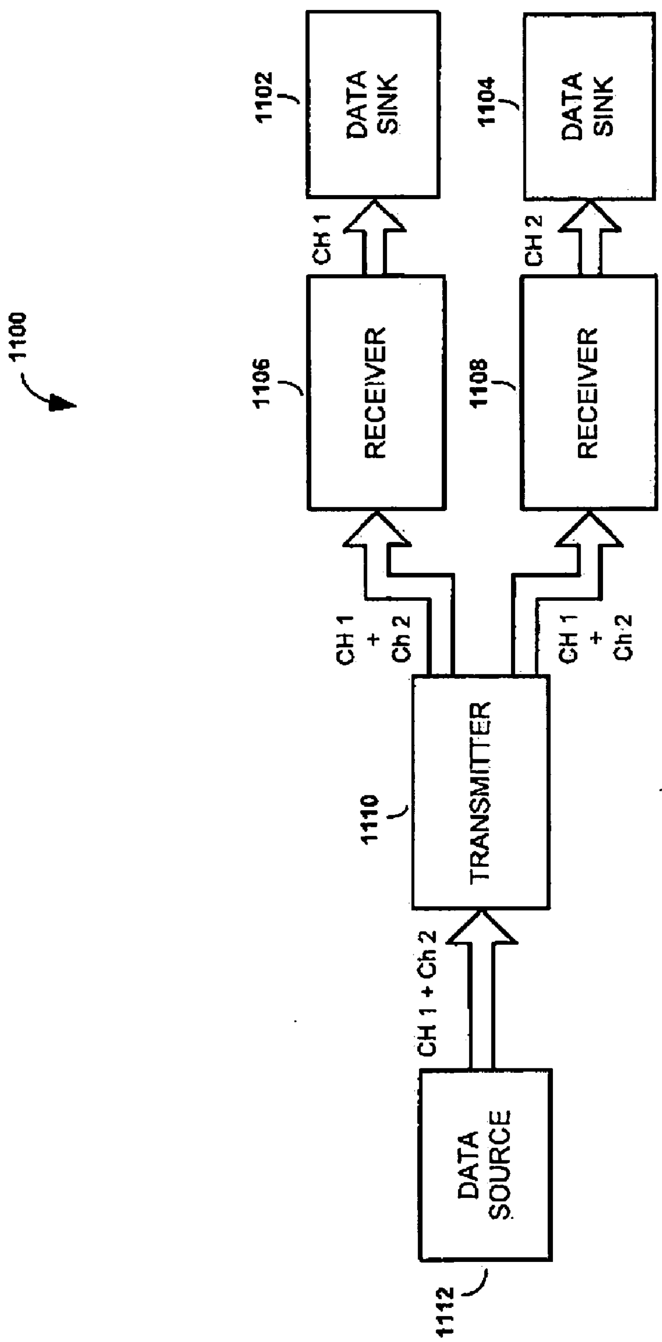

1100
1102
DATA SINK
1104
DATA SINK
CH 1
CH 2
1106
RECEIVER
1108
RECEIVER
CH 1 + Ch 2
CH 1 + Ch 2
1110
TRANSMITTER
CH 1 + Ch 2
DATA SOURCE
1112

FIGURE 11

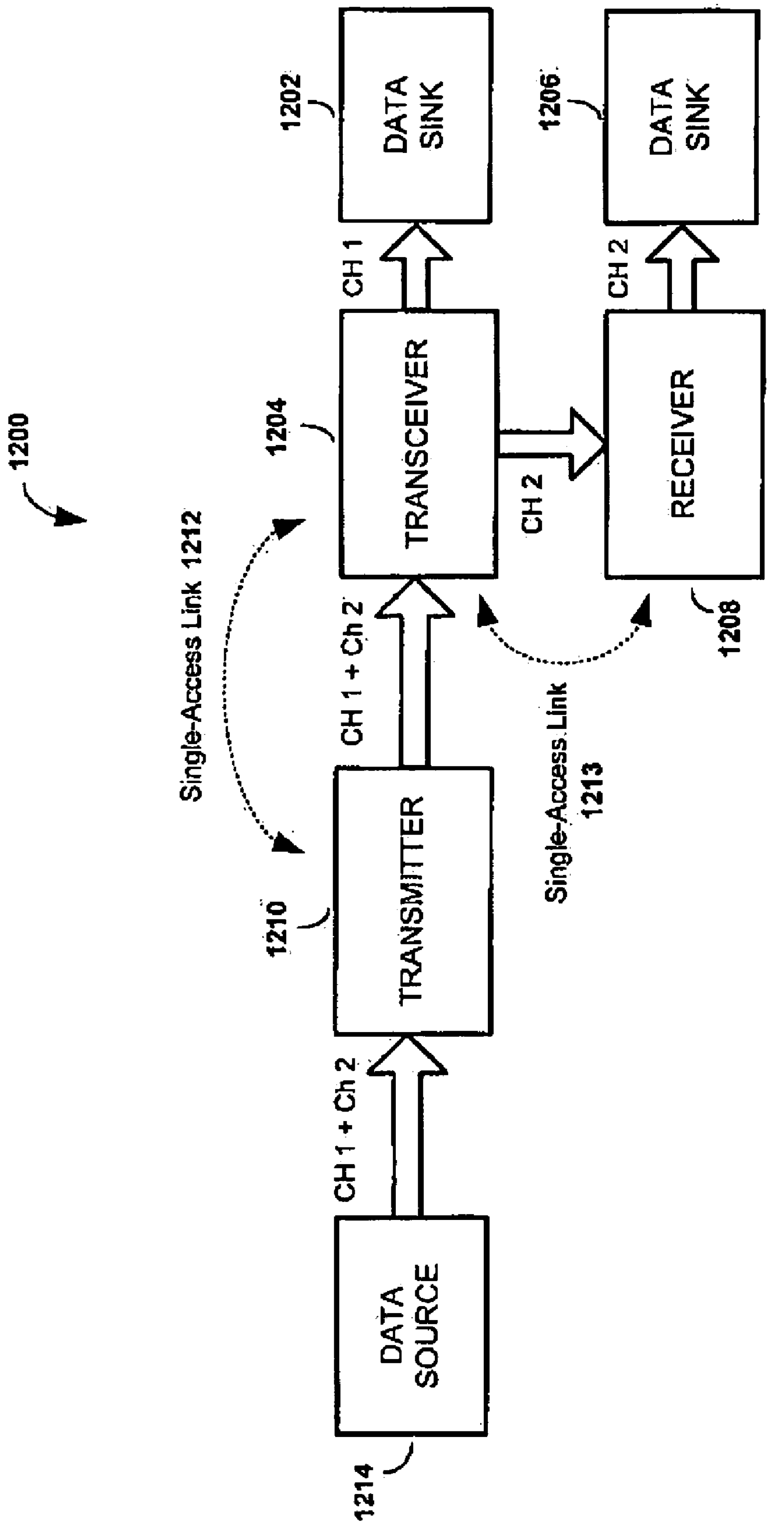

1200
1202
DATA SINK
1206
DATA SINK
CH 1
CH 2
1204
TRANSCEIVER
CH 2
RECEIVER
1208
Single-Access Link 1212
CH 1 + Ch 2
Single-Access Link 1213
1210
TRANSMITTER
CH 1 + Ch 2
DATA SOURCE
1214

FIGURE 12

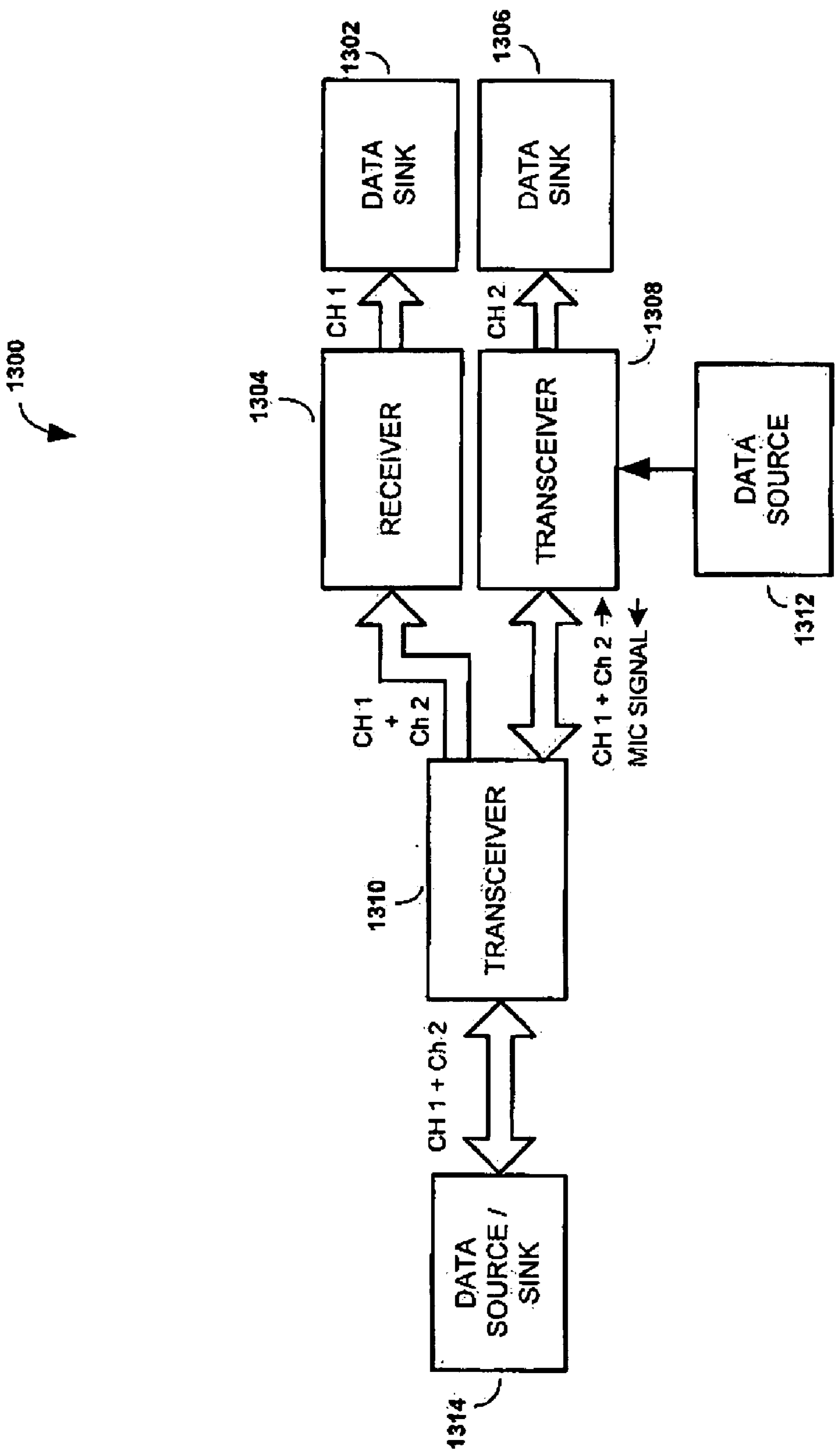

1300
1302
DATA SINK
1306
DATA SINK
CH 1
CH 2
1304
RECEIVER
TRANSCEIVER
1308
DATA SOURCE
1312
CH 1 + Ch 2
CH 1 + Ch 2
MIC SIGNAL
1310
TRANSCEIVER
CH 1 + Ch 2
DATA SOURCE / SINK
1314

FIGURE 13

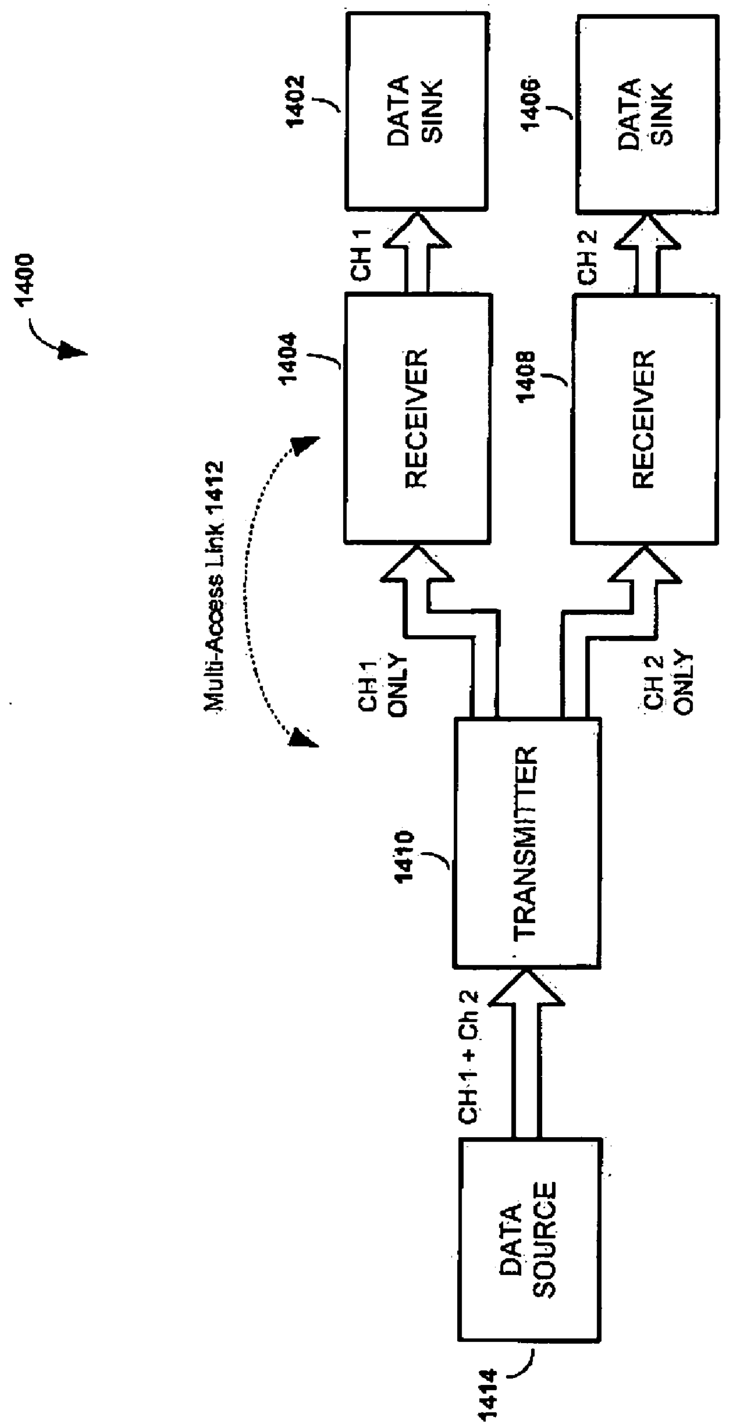

1400
1402
DATA SINK
CH 1
1404
RECEIVER
1406
DATA SINK
CH 2
1408
RECEIVER
Multi-Access Link 1412
CH 1 ONLY
CH 2 ONLY
1410
TRANSMITTER
CH 1 + Ch 2
DATA SOURCE
1414

FIGURE 14

PHYSICALLY AND ELECTRICALLY-SEPARATED, DATA-SYNCHRONIZED DATA SINKS FOR WIRELESS SYSTEMS

FIELD OF THE INVENTION

[0001] The present invention relates to wireless systems. More particularly, the present invention relates to wireless communication between a data source and two or more and physically and electrically-separated wireless data sinks such as, for example, wireless earphones.

BACKGROUND OF THE INVENTION

[0002] Headphones have come into widespread use ever since they were invented in the late 1930s. Today, headphones are used in numerous industrial settings, for listening to music and radio broadcasts, and for receiving voice communications from mobile telephones. A conventional pair of headphones comprises a pair of sound transducers (i.e., speakers), which are configured to receive electrical signals from an audio source (e.g., compact disk (CD) player, digital audio player (MP3 player), cellular telephone, personal digital assistant (PDA), or personal computer) and provide sound to a user's ears.

[0003] FIGS. **1**A and **1**B are illustrations of a user **100** wearing two different types of early-model headsets The headset in FIG. **1**A comprises a pair of headphones **102**, **104**, a headband **106** and a pair of electrical cables **108**, **110**, which connect the headphones **102**, **104** to an external audio source. The headband **106** is worn over the top of the user's **100** head, and physically connects the pair of headphones **102**, **104**. A cable clip **112** may be used to secure the electrical cables **108**, **110** so that they do not interfere with the movement of the user **100** and to prevent tangling of the electrical cables **108**, **110**. The headset in FIG. **1**B is similar to the headset in FIG. **1**A, except that only a single electrical cable **114** is connected between one of the headphones **102**, **104** and the audio source. Because cabling is provided only to a single headphone **102**, electrical wiring is routed through the headband **106** to electrically connect the headphones **102**, **104**. The headsets in FIGS. **1**A and **1**B are often referred to in the art as "binaural" headsets since they each comprise a headset having a pair of headphones **102**, **104** for each of the user's **100** ears.

[0004] Recent advances in wireless technology have allowed the design and manufacture of wireless headsets. For example, the recent introduction of the Bluetooth industrial specification (also known as the IEEE 802.15.1 standard) allows a user to establish a short range wireless personal area network (PAN) in which various electronic devices (e.g., cell phones, PDA's, MP3 players, personal computers, printers, etc.) can communicate with each other over wireless links. Because the PAN is a radio communication system using low gain antennas, the Bluetooth enabled devices do not have to be in line of sight of each other. Furthermore, because the PAN is completely wireless, the clutter and obstruction of electrical cables can be avoided.

[0005] FIG. **2** is an illustration of a user **200** wearing a binaural Bluetooth enabled headset. Similar to the wired headsets in FIGS. **1**A and **1**B, the Bluetooth enabled headset in FIG. **2** comprises a pair of headphones **202**, **204** and a headband **206**, which physically connects the pair of headphones and provides support for positioning the headset over the user's **200** head. Electrical wiring within the headband **206** electrically connects the pair of headphones **202**, **204**. Rather than using electrical cabling between the headphones **202**, **204** and the external audio source, as is done in the conventional wired headsets in FIGS. **1**A and **1**B, one of the headphones **202**, **204** of the Bluetooth enabled headset includes a Bluetooth transceiver that wirelessly communicates with a Bluetooth enabled external audio source **208** over a wireless link **210**.

[0006] The binaural wireless headset in FIG. **2** does afford the benefits of wireless operation. However, similar to the traditional wired headsets shown in FIGS. **1**A and **1**B, the headphones **202**, **204** are physically connected by a headband **206**. Some users find wearing a headband to be uncomfortable and/or disruptive to their headdress or coiffure.

[0007] One way to avoid the drawbacks associated with use of a headband is to use a pair of conventional wired earbuds. An earbud is a small headphone that fits into the concha of the pinna of the user's ear. FIG. **3** shows a user **300** wearing a pair of wired earbuds **302**, **304**. A pair of electrical cables **306**, **308** connects transducers within the earbuds **302**, **304** to an external audio source. A cable clip **310** may also be used to secure the electrical cables **306**, **308** so that they do not interfere with the movement of the user **300** and to prevent tangling of the electrical cables **308**, **310**. While use of earbuds does avoid the drawbacks of having to wear a headband, their use still requires cabling (i.e. wires) between the earbuds and the external audio device.

[0008] Another type of headset that avoids the use of a headband is the Bluetooth enabled over-the-ear wireless headset. This type of headset is known in the art as a "monaural" headset, since it operates with only one of the user's two ears. FIG. **4** is an illustration of a user **400** wearing a Bluetooth enabled over-the-ear wireless headset. The headset includes a headphone **402** and an earloop **404** that is configured to fit around the outer ear of the user **400**. The headphone **402** includes a single audio transceiver for placement near the ear and a voice tube **406** for directing sound from the user's voice to a microphone within the headphone housing. The single audio transceiver communicates with an external wireless audio device **408** (e.g., a cellular telephone) over a wireless link **410**.

[0009] Because the Bluetooth enabled over-the-ear wireless headset is monaural, it is incapable of providing high-fidelity stereo audio to the user **400**. For this reason, such devices are used primarily for enabling hands-free operation of a mobile telephone and not for listening to music.

[0010] Each of the various types of prior art headsets described above has its own unique benefits and drawbacks. For example, a benefit of the conventional wired binaural headsets in FIGS. **1**A and **1**B are that they are relatively inexpensive to manufacture and acquire. A benefit of the binaural Bluetooth enabled headset in FIG. **2** is that it is wireless and provides stereo audio. Unfortunately, each of these three types of headsets requires the use of a headband and/or an electrical connection (i.e., electrical wiring) between the two headphones of the headset. The earbud type headset is beneficial in that it obviates the need for a headband. However, the earbuds are also wired, i.e., require cabling to electrically connect the transducers in the earbuds to an external audio device. Finally, whereas the Bluetooth enabled over-the-ear wireless headset avoids both the need

for a headband and the need for cabling to connect to an external audio device, it is, unfortunately, monaural. Consequently, it is incapable of providing high-quality stereo sound to a user.

BRIEF SUMMARY OF THE INVENTION

[0011] Wireless systems having a plurality of physically and electrically-separated data sinks are disclosed. An exemplary wireless system includes first and second data sinks having no physical or electrical connection therebetween. The first and second data sinks each include a wireless communication device, e.g., a radio frequency (RF) receiver or transceiver configured to receive data signals over one or more single-access wireless links or over a multi-access wireless link. The first and second data sinks in exemplary embodiments described herein comprise audio data sinks, e.g., left-ear and right-ear earphones (e.g., earbuds or canalphones), left-ear and right-ear circum-aural over-the-ear headphones, stereo speakers, speakers for a surround sound system, etc. At least one of the first and second data sinks may also be coupled to a wireless transmitter and accompanying data source (e.g., a microphone or sensor), so as to provide, for example, two-way communications between a user and an external data device (e.g., a cellular telephone). Those of ordinary skill in the art will readily appreciate and understand that the inventions defined by the claims attached hereto are not be limited to or by the summary of the exemplary embodiments provided here or to or by the detailed description of the exemplary embodiment set forth below.

[0012] Further features and advantages of the present invention, as well as the structure and operation of the various exemplary embodiments of the present invention, are described in detail below with respect to accompanying drawings, in which like reference numbers are used to indicate identical or functionally similar elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1**A is an illustration of a user wearing a prior art headset comprising a pair of headphones connected by a headband, where both headphones are connected to a pair of cables leading to an external audio source;

[0014] FIG. **1**B is an illustration of a user wearing a prior art headset comprising a pair of headphones connected by a headband, where only one of the pair of headphones is connected to a cable leading to an external audio source, and where the headphones are electrically coupled by wiring within the headband of the headset;

[0015] FIG. **2** is an illustration of a user wearing a prior art binaural Bluetooth enabled headset having a headband that physically connects the two headphones of the headset;

[0016] FIG. **3** is an illustration of a user wearing a pair of prior art wired earbuds;

[0017] FIG. **4** is an illustration of a user wearing a prior art Bluetooth enabled over-the-ear monaural wireless headset;

[0018] FIG. **5** is an illustration of a user wearing a wireless headset comprising first and second wireless earphone, in accordance with an embodiment of the present invention;

[0019] FIG. **6** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0020] FIG. **7**A is a diagram of a two-stage transmitter that may be used to implement each of the first and second transmitters in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0021] FIG. **7**B is a diagram of a direct conversion transmitter that may be used to implement each of the first and second transmitters in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0022] FIG. **8**A is a diagram of a superheterodyne receiver that may be used to implement each of the first and second receivers in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0023] FIG. **8**B is a diagram of a direct conversion receiver that may be used to implement each of the first and second receivers in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0024] FIG. **9** is a diagram of an RF transceiver that may be used in place of one or more of the RF transmitters and receivers of the various disclosed embodiments, in accordance with embodiments of the present invention;

[0025] FIG. **10** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0026] FIG. **11** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0027] FIG. **12** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0028] FIG. **13** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention; and

[0029] FIG. **14** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0030] FIG. **5** is an illustration of a user **500** wearing a wireless headset comprising first and second wireless earphones **502**, **504**, in accordance with an embodiment of the present invention. Each of the first and second wireless earphones **502**, **504** comprises a housing containing a speaker, an RF receiver or transceiver and a battery. The speaker may comprise, for example, a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements. As explained in detail below, the receiver or transceiver of each of the first and second earphones **502**, **504** is operable to communicate with one or more external data or audio data devices (e.g., a cellular telephone, PDA, MP3 player, CD player, radio, personal computer, game console, etc.) over one or more wireless links. Each of the first and second earphones **502**, **504** may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear; a canalphone, which can be fitted within the ear canal of the user's ear; an over-the-ear circum-aural type headphone; or any other suitable configuration that may be attached to, worn on, or fitted within the user's ear. Each of the first and

second earphone **502**, **504** may further include a clip, earloop, or other suitable securing mechanism to help maintain the earphone **502** or **504** on the ear of the user. Either or both of the first and second earphones **502**, **504** may further be coupled to a second data or audio data source such as, for example, a sensor or a microphone for capturing sound waves generated by the user's **500** voice.

[0031] FIG. **6** is a diagram showing a wireless system **600** that may be used to wirelessly transmit data signals to first and second data sinks **602**, **606**, in accordance with an embodiment of the present invention. According to this and other exemplary embodiments of the invention, the data signals may comprise audio data signals, and the first and second data sinks **602**, **606** may correspond to the first and second earphones **502**, **504** in FIG. **5**. The first data sink **602** is electrically coupled to a first radio frequency (RF) receiver **604** and the second data sink **606** is electrically coupled to a second RF receiver **608**. The first and second RF receivers **604**, **608** may be analog or digital receivers.

[0032] A first RF transmitter **610** is adapted to be wirelessly coupled to the first RF receiver **604** over a first single-access wireless link **612**, and a second RF transmitter **614** is adapted to be wirelessly coupled to the second RF receiver **608** over a second single-access wireless link **616**. The first and second RF transmitters **610**, **614** may be analog or digital transmitters. Further, in an alternative embodiment, one or more of the first and second RF receivers **604**, **608** and first and second RF transmitters **610**, **614** may comprise one or more RF transceivers, which allow communication in both directions of the first and second single-access wireless links **612**, **616**.

[0033] The first and second RF transmitters **610**, **614** are adapted to receive data signals from a data source **618**. The data source **618** may comprise a digital data source or an analog data source. For example, the data source **618** may be provided from a digital audio data output of an MP3 player, CD player, PC, PDA, mobile telephone, game console, component of an entertainment system, etc. If the data source **618** is an analog data source, and the RF transmitters **610**, **614** are digital transmitters, an analog-to-digital converter (A/D converter) may be provided, either as part of the processing circuitry of the RF transmitter **610** or external to the RF transmitter **610**, to convert the analog data signals to digital data signals.

[0034] In the wireless system **600** shown in FIG. **6**, the data source **618** is electrically coupled to both the first and second transmitters **610**, **614**, as indicated by the "CH **1**" and "CH **2**" labels in the drawing. According to an exemplary embodiment, the data provided by the data source **618** comprises first and second digital data streams having data packets formatted in compliance with any one of various wireless technologies. For example, Gaussian Frequency-Shift Keying (GFSK) or Frequency-Shift Keying (FSK) are two exemplary modulation schemes that may be used to. The baseband portions of the first and second RF transmitters **610**, **614** may also be configured to operate on the data packets to provide error correction, source encoding and/or channel encoding for error minimization, compression and/or data redundancy purposes.

[0035] According to an aspect of the invention, the baseband portion of the first and second RF transmitters **610**, **614** in the embodiment of the invention shown in FIG. **4**, as well as in other embodiments in this disclosure, process and configure the incoming data from the data source **618** into data packets compliant with the Bluetooth radio standard. Details concerning the Bluetooth radio standard may be found in "Bluetooth End-to-End" by Dee Bakker, Diane McMichael Gilster and Ron Gilster, Hungry Minds, Inc., 2002 (ISBN: 0-7645-4887-5), which is incorporated into this disclosure by reference. Those of ordinary skill in the art will readily appreciate and understand that, whereas the Bluetooth radio standard may be used, that other low power radio standards and communication protocols may alternatively be used.

[0036] As shown in FIG. **6**, the data signals from the data source **618** are separated into first and second data streams. The first and second data streams are modulated onto RF carriers by the first and second RF transmitters **610**, **614** and wirelessly transmitted to the first and second RF receivers **604**, **608**, via the first and second single-access wireless links **612**, **616**. Upon receiving the first and second data streams, the first and second RF receivers **604**, **608** down-convert the modulated RF carriers and electrically couple the demodulated first and second data streams to the first and second data sinks **602**, **606**. The baseband portions of the first and second RF receivers **604**, **608** may also contain, if necessary, a digital-to-analog (D/A) converter and/or other or additional processing circuitry to facilitate the electrical coupling of the first and second RF receivers **604**, **608** to the first and second data sinks **602**, **606**. Alternatively, such components may be included as part of the data sinks **602**, **606** themselves. These additional conversion and signal processing aspects may also be applied to other embodiments of the invention disclosed herein.

[0037] If the first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** are implemented as digital transmitters and receivers, the first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** may include data buffers to compensate data packet losses. To compensate for data packet losses, which may be caused by, for example, radio interference, data buffers may be included in each of the first and second RF transmitters **610**, **614**. Accordingly, if a data packet is lost or for some reason not received by an intended one of the first and second RF receivers **604**, **608**, the receiver not receiving the data packet may request a resend (ARQ). So long as the communication rate between the requesting receiver and the corresponding transmitter is faster than the data consumption rate of the receivers, the resending of the data packet results in no loss of information to the corresponding data sink **602** or **604**.

[0038] Timing differences between the first and second data streams may also be of concern, particularly in applications where the data packets comprise audio data. Audio data can be monophonic or stereophonic. In either case, a listener does not perceive delay differences (differential latency) between the left and right speakers (i.e., left and right data sinks **602**, **604**), so long as the audio data packets in the first and second data streams arrive at the first and second data sinks **602**, **606** within about 100 μs of each other. Nevertheless, in some circumstances either or both of the analog-to-digital (A/D) converters of the first and second RF receivers **604**, **608** may consume data faster or slower than the data provided by the first and second RF transmitters **610**, **614**. If either one of the A/D converters is too slow, data sent by the corresponding one of the first and second RF transmitters **610**, **614** will be lost at the sending end since the data has no place to go. On the other hand, the A/D converter

will stall if it operates too fast, since it will run out of data faster than data is provided to it.

[0039] There are a number of ways to compensate for differential latencies between the first and second data streams. One way is to include data buffers in each of the first and second RF receivers **604**, **608** and control the buffers so that they maintain a predetermined constant occupancy. So, for example, if the data occupancy of a data buffer of one of the first and second RF receivers **604**, **608** becomes too low (e.g., due to a fast A/D converter), interpolated or repeated data samples may be inserted into the data buffer to increase the data occupancy of the buffer, thereby forcing the buffer to maintain the intended predetermined data occupancy. Conversely, if the data occupancy of the data buffer becomes too high (e.g., due to a slow A/D converter) data samples may be removed from the buffer to reduce the data occupancy.

[0040] Another way to synchronize the first and second data streams (i.e., reduce the differential latency of the first and second data streams) is to embed the data sample clock used by the first and second RF transmitters **610**, **614** in the RF carrier signals used to carry the first and second data streams over the first and second wireless links **612**, **616**. This may be accomplished by, for example, modulating each of the RF carrier signals associated with the first and second RF transmitters **610**, **614** with analog subcarrier signals, which are synchronized with the data source sample clock used at the transmitting end of the system **600**. The subcarrier signals can be detected by the respective first and second RF receivers **604**, **608** and converted into digital clocks which can drive the A/D converters of the first and second RF receivers **604**, **608**.

[0041] Yet still another way to reduce the differential latency of the first and second data streams is to exclusive OR a pseudo-random noise sequence (PRNS) into the digital modulation of the carrier signals, similar to as is used by the TIA/IS-95 radio standard. If the PRNS used for the first and second data streams is sufficiently long, the PRNS can be correlated at the first and second RF receivers **604**, **608**, and the delay between the send and receive clocks can be deduced.

[0042] Finally, but not necessarily lastly, the differential latency between the first and second data streams may be reduced by monitoring the data buffers or delays, and adjusting the clock signals used by the A/D converters of the first and second RF receivers **604**, **608**. Accordingly, if the occupancy of a data buffer of one of the first and second RF receivers **604**, **608** is too low (or the receive clock/sample clock delay is decreasing), the A/D clock is slowed down. Conversely, if it is determined that the occupancy of the data buffer is too high (or the delay is increasing), the A/D clock is sped up.

[0043] The first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** may be implemented in various ways. Below is a description of a few examples of how the transmitters and receivers may be implemented. Those of ordinary skill in the art will appreciate and understand that these transmitter and receiver implementations are provided here for illustrative purposes only and that other types of transmitters and receivers may alternatively be used.

[0044] FIG. **7**A is a diagram of a two-stage (heterodyne) transmitter **700** that may be used to implement each of the first and second transmitters **610**, **614** in the wireless system **600** in FIG. **6**. The two-stage transmitter **700** comprises a quadrature modulator **702**, a first band-pass filter **704**, an RF upconverter **706**, a second band-pass filter **708** an RF power amplifier **710**, and an antenna **712**. The quadrature modulator **702** is operable to receive in-phase (I) and quadrature (Q) channels of the first data stream from the data source **618** and upconvert the data to an intermediate frequency (IF). If necessary, data from the data source **618** may be coupled to a signal conditioning circuit **701** to provide analog-to-digital conversion, filtering, amplification and/or other signal processing functions, before the data is coupled to the baseband portion (i.e., baseband processor **703**) of the transmitter **700**. The first band-pass filter **704** suppresses harmonics generated by the IF modulation process and provides the filtered output to the RF upconverter **706**, which operates to upconvert the filtered IF signal to RF. The second band-pass filter **708** removes unwanted sidebands generated by the RF upconversion process and couples the filtered output to an input of the RF power amplifier **710**. The RF power amplifier **710** amplifies the filtered signals and couples the data modulated RF signal to the antenna **712**, which radiates the modulated RF signal to the first RF receiver **604** over the first single-access wireless link **612**. A second two-stage transmitter operates similarly to upconvert and modulate the I and Q channels of the second data stream from the data source **618** onto an RF carrier signal, which is radiated to the second RF receiver **608** over the second single-access link **616**.

[0045] FIG. **7**B is a diagram of a direct conversion (homodyne) transmitter **750** that may be used to implement each of the first and second transmitters **610**, **614** in the wireless system **600** in FIG. **6**. The direct conversion transmitter **750** comprises a quadrature modulator **752**, a band-pass filter **754**, an RF power amplifier **756**, and an antenna **758**. Rather than using two two-stage transmitters **700** to upconvert the first and second data streams to RF, as is may be done with the two-stage transmitter **700** in FIG. **7**A, two direct conversion transmitters **750** may be used. By using a local oscillator frequency that is equal to the RF carrier frequency, the two direct conversion transmitters are operable to directly upconvert the first and second data streams to modulated RF carriers in a single upconversion process.

[0046] FIG. **8**A is a diagram of a superheterodyne receiver **800** that may be used to implement each of the first and second receivers **604**, **608** in the wireless system **600** in FIG. **6**. The superheterodyne receiver **800** comprises a front-end stage, an RF downconverter, an automatic gain control (AGC) amplifier **816**, and a baseband quadrature demodulator **818**. The front-end stage comprises an antenna **802**, a first band-pass filter **804**, a low-noise amplifier (LNA) **806**, and a second band-pass filter **808**. The RF dowconverter comprises a first mixer **810**, a first local oscillator **812**, and a third band-bass filter **814**.

[0047] The first band-pass filter **804** filters the modulated RF signal received by the antenna **802** to preselect the intended frequency band of interest from noise and other unwanted signals, and protects the rest of the receiver **800** from saturation by interfering signals at the antenna **802**. The LNA **806** amplifies the filtered signal and couples its output to the second band-pass filter **808**, which operates as an image reject filter, protects the RF downconverter from out-of-band interferer signals, and suppresses undesired spurious signals generated by the first mixer **810** of the RF downconverter. Filtered signals from the second band-pass

filter **808** are coupled to the mixer **810** of the RF downconverter, which operates to transfer the modulation on the RF signal to IF. Spurious products generated by the mixer **810** are filtered out by the third band-pass filter **814**. The filtered IF signal is then coupled to an input of the AGC amplifier **816**, which operates to maintain as wide a dynamic range as possible for varying levels of RF received by the receiver **800**. The baseband quadrature demodulator **818** extracts the baseband signals from the IF. The extracted baseband signals are digitized by analog-to-digital (A/D) converters **820**, **822** and transmitted to a baseband processor **824**. Processed data from the baseband processor **824** is then coupled to the first and second data sinks. To ensure that the processed data is in a form suitable to drive the first and second data sinks **602**, **606**, the processed data from the baseband processor **824** may be first coupled to a signal conditioning circuit **826** to provide digital-to-analog conversion, filtering, amplification, and/or other signal processing functions.

[0048] The first and second receivers **604**, **608** in the wireless system **600** in FIG. **6** may alternatively be downconverted using a direct conversion (or "zero IF") receiver. FIG. **8**B is a diagram of a direct conversion receiver **850** that may be used to implement these functions. The direct conversion receiver **850** operates similar to the superheterodyne receiver **800** in FIG. **8**A except that the conversion is performed in one step. Because the RF signals are downconverted in a single operation, there is no need for an image reject filter (second band-pass filter **808** in FIG. **8**A) at the front end of the receiver **850**.

[0049] Whereas the wireless system **600** above has been described as comprising RF transmitters and RF receivers, in an alternative embodiment RF transceivers containing both an RF transmitter and an RF receiver may be used in place of each of the RF transmitters **610**, **614** and RF receivers **604**, **608**. The same alteration is also applicable to the other embodiments set forth in this disclosure. FIG. **9** is a block diagram of an RF transceiver **900** that may be used for this purpose. The RF transceiver **900** comprises an RF transmitter portion **902**, an RF receiver portion **904**, an antenna **906**, and a duplexer **908**. The duplexer **908** operates to isolate the transceiver portion **904** from the transmitter portion **902**. An A/D converter **910** receives downconverted analog baseband signals from the RF transceiver portion **904**, digitizes the signals, and sends the digitized baseband signals to a baseband processor **914**. If necessary, the processed data from the baseband processor **914** may be coupled to a signal conditioning circuit **916** to provide digital-to-analog conversion, filtering, amplification, and/or other signal processing functions, to ensure that the processed data is in a form suitable to drive the data sink **918**.

[0050] For the RF transmitter portion **902**, a D/A converter **912** is adapted to receive data signals from a data source **922** and operable to convert the data signals into analogs signals, which are upconverted to RF by the RF transmitter in preparation of being radiated over the appropriate wireless link by the antenna **906**. If necessary, data from the data source **922** may be coupled to a signal conditioning circuit **920** to provide analog-to-digital conversion, filtering, amplification and/or other signal processing functions, before the data is coupled to the baseband processor **914**.

[0051] While the exemplary RF transceiver **900** in FIG. **9** has been shown and described as comprising an RF transmitter portion **902** and an RF receiver portion **904** that share the same antenna and use a common wireless technology, an alternative RF transceiver design may comprise an RF transmitter portion and receiver portion configured to use separate antennas. The RF transceiver may further include additional circuitry and processing capabilities that allow the RF transmitter and receiver portions to operate in accordance with different wireless technologies.

[0052] As discussed above, the wireless system **600** in FIG. **6** uses a separate transmitter/receiver pair or transceiver/transceiver pair (if transceivers are used) for each channel. Because each transmitter/receiver pair is dedicated to a single channel, the data rate in each channel can be lower than the data rate that would be necessary if both of the separated data streams were transmitted over each wireless link **612**, **616**. The lower data rate over the first and second single-access wireless links **612**, **616** allows the use of more economical electrical components, and allows the system components to operate at lower power levels. Furthermore, this embodiment of the present invention allows for independent power control of the transmitter/receiver or transceiver/transceiver pairs, which allows each transmitter/receiver or transceiver/transceiver pair to consume only as much power as is required to communicate.

[0053] In some applications, however, it may not be possible to reduce the data rate, or it may be desirable for one reason or another to maintain both the first and second data streams on the same wireless link. If such circumstances arise, the wireless system **1000** shown in FIG. **10** may be used. According to this embodiment of the invention, data for both the first and second data sinks **1016**, **1018** (e.g., audio data intended for both the right-ear and left-ear earphones **502**, **504**) are both transmitted on each of single-access wireless links **1004**, **1006**. The first and second receivers **1008**, **1010** are each configured to receive both the first and second data streams from the first and second transmitters **1012**, **1014** and couple only the appropriate one of the data streams to the first and second data sinks **1016**, **1018** of the system. Compensation for data packet loss and differential latency of the first and second data streams may be accomplished using techniques similar to those described above for the embodiment shown in FIG. **6**. Further those techniques, or similar techniques, may be applicable to other embodiments disclosed herein.

[0054] According to an alternative embodiment of the invention shown in FIG. **11**, a single source transmitter (or source transceiver) **1102** may be used to broadcast data from the data source **1112** to first and second RF receivers **1106**, **1108**, instead of the first and second transmitters **1012**, **1014** used in the embodiment shown in FIG. **10**. Those of ordinary skill in the art will readily appreciate and understand that the wireless system **1100**, as well as the other embodiments set forth in this disclosure, may comprise either analog or digital radio techniques. In the case of a digital implementation, differential latency of data received by the first and second RF receivers **1106**, **1108** may be reduced or maintained at a predetermined level by including data buffers in the first and second RF receivers **1106**, **1108**. By controlling and maintaining the data occupancy of the data buffers at some constant predetermine data occupancy level, similar to that described above in connection with the embodiment shown in FIG. **6**, the differential latency can be reduced or maintained at predetermined levels.

[0055] Referring now to FIG. **12**, there is shown a wireless system **1200** that may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., first

and second earphones **502**, **504** in FIG. **5**), in accordance with an alternate embodiment of the present invention. The wireless system **1200** includes a single RF transmitter **1210**, which is adapted to be wirelessly coupled to an RF transceiver **1204** over a first single-access wireless link **1212**. The RF transmitter **1210** operates to wirelessly transmit data streams intended for both the first and second data sinks **1202**, **1206** to the RF transceiver **1204**. The RF transceiver **1204** receives the data modulated onto the RF carrier, downconverts the data modulated RF carrier, and couples the data needed only for operation of the first data sink **1202** (e.g., right channel stereo indicated as "CH **1**" in the drawing) to the first data sink **1202**. A transmitter portion of the RF transceiver **1204** transmits data needed only for the operation of the second data sink **1206** to an RF receiver **1208** over a second single-access wireless link **1213**. The RF receiver **1208** operates to downconvert the data modulated signal and couple the downconverted data to the second data sink **1206**. Communication between the transmitter portion of the RF transceiver **1204** and the receiver **1208** may be conducted in accordance with the same or similar wireless technology as used by the source transmitter **1210** and the receiver portion of the RF transceiver **1204**, or may use a different wireless technology. As in other embodiments disclosed herein, the receiver portion of the RF transceiver **1204** and the receiver **1208** may include data buffers that are controlled to compensate for, or reduce the differential latency of, data arriving at the first and second data sinks **1202**, **1206**. In particular, the data buffer occupancies of the RF transceiver **1204** and/or the receiver **1208** can be controlled to compensate for the delay imparted to the data routed through the RF receiver **1208**, so that the differential latency between data arriving at the first data sink **1202** and data arriving at the second data sinks **1206** is reduced or controlled to within some predetermined threshold.

[0056] According to an embodiment of the invention, either or both the first and second data sinks of the various embodiments may include (or be coupled to) a data source such as, for example, a sensor or a microphone to allow a data to be sent back to an external electronic device. FIG. **13** shows a wireless system **1300** that may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., the first and second earphones **502**, **504** in FIG. **5**, and also provide data signals back to the external electronic device, in accordance with an alternate embodiment of the present invention. The wireless system **1300** comprises first and second data sinks **1302**, **1306**, which are electrically coupled to an RF receiver **1304** (or transceiver) and a first RF transceiver **1308**, respectively. A second RF transceiver **1310** is adapted to be wirelessly coupled to the RF receiver **1304** and the first RF transceiver **1308**. The second RF transceiver **1310** is adapted to receive data from a data source **1314** and broadcast an RF carrier, which is modulated by the data, to both the receiver **1304** and the first RF transceiver **1308**. The second RF transceiver **1310** is also adapted to receive data modulated carrier signals (e.g., voice data modulated carrier signals) in the reverse direction from the first RF transceiver **1308**, which receives data signals from a data source **1312** comprising, for example, a sensor or a microphone. The data modulated signals are downconverted by the second RF transceiver **1310** and coupled to a data source/data sink **1314**. The data signal extracted may then be provided as data signals to an external electronic device, e.g., an external audio device. Those of ordinary skill in the art will readily appreciate and understand that a similar data source may also be incorporated in any on of the other embodiments described in this disclosure.

[0057] Those of ordinary skill in the art will readily appreciate and understand that the wireless system **1300**, as well as the other embodiments set forth in this disclosure, may comprise either analog or digital radio techniques. In the case of a digital implementation, differential latency of data received by the RF receiver **1304** and the receiver portion of the first RF transceiver **1308** may be reduced or maintained at a predetermined level by including data buffers in the RF receiver **1304** and the receiver portion of the first RF transceiver **1308**. By controlling and maintaining the data occupancy of the data buffers at some constant predetermine data occupancy level, similar to that described above in connection with the embodiment shown in FIG. **6**, the differential latency can be reduced or maintained at predetermined levels.

[0058] FIG. **14** is a diagram of a wireless system **1400**, in accordance with another embodiment of the present invention. Similar to the previously described embodiments, the wireless system **1400** may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., to the first and second earphones **502**, **504** in FIG. **5**). The wireless system **1400** includes a single multi-access RF transmitter (or transceiver) **1410**, which is adapted to be wirelessly coupled to first and second multi-access RF receivers (or transceivers) **1404**, **1408** over a multi-access wireless link **1412**. Data packets from a data source are separated (or "multiplexed") by use of distinct codes or time slots that are uniquely assigned to the first and second RF receivers **1404** and **1408**. The multi-access RF transmitter **1410** transmits the data packets according to the time slots or codes over the multi-access wireless link **1412**. The RF receivers **1404**, **1408** operate to extract and downconvert their intended data packets based on the time slots or codes uniquely allocated to them. Those of ordinary skill in the art will readily appreciate that, similar to the embodiments described above, the first and second RF receivers **1404**, **1408** may include data buffers that are controlled so that the data provided to the first and second data sinks **1402**, **1404** have a differential latency that is at or below a predetermined threshold.

[0059] Any one of a number of multi-access data protocols may be employed by the wireless system **1400**. As an example, time domain multiple access (TDMA) multiplexing may be used. TDMA multiplexes the data packets of the first and second data streams in time so that the RF transmitter **1410** may transmit the time multiplexed data packets in time slots. The first and second receivers **1404**, **1408** are synchronized with the RF transmitter **1410** so that appropriate data packets modulated on the RF carrier over the multi-access link **1412** can be extracted by the first and second RF receivers **1404**, **1408** during their allocated time slots.

[0060] Code domain multiple access (CDMA) is another multi-access data protocol that may be used in the multi-access wireless system **1400** in FIG. **14**. Rather than using time to multiplex the data packets of the first and second data streams, CDMA operates to encode, and thereby multiplex, the data packets with orthogonal codes that are uniquely assigned and known by the first and second RF receivers **1404**, **1408**. The first and second RF receivers **1404**, **1408** are then only capable of extracting data packets having the

unique codes assigned to them. Details of the CDMA and TDMA multi-access protocols may be found in "Principles of Wireless Networks: A Unified Approach" by P. Krishnamurthy and K. Pahlavan, Prentice Hall, 2002 (ISBN: 0-130-93003-2), and "RF System Design of Transceivers for Wireless Communications" by Q. Gu, Springer Science—Business Media, Inc., 2005 (ISBN: 0-387-24161-2), both which are incorporated into this disclosure by reference.

[0061] Although the present invention has been described with reference to specific embodiments thereof, these embodiments are merely illustrative, and not restrictive, of the present invention. Various modifications or changes to the specifically disclosed exemplary embodiments will be suggested to persons skilled in the art. For example, while some of the various disclosed embodiments have been described in the context of wireless systems for wireless earphones, the apparatus, systems and methods disclosed herein are applicable to any application in which a plurality of unconnected wireless data sinks is desirable. For example, the various disclosed embodiments may be used to form a home entertainment system in which the plurality of data sinks correspond to a plurality of physically unconnected wireless speakers.

[0062] Furthermore, while the various exemplary embodiments herein are described as containing first and second data sinks, those of ordinary skill in the art will readily appreciate and understand that the general concept of wireless transmission to physically unconnected wireless data sinks may be applied to wireless systems with more than two data sinks (e.g., for a fully wireless surround sound type system).

[0063] Still further, whereas the various disclosed embodiments have been described as transmitting and receiving RF signals, the transmitters, receivers and transceivers may alternatively be configured to transmit and receive according to other types of wireless techniques, e.g., optical, ultrasound, non-radiated wireless techniques such as over-the-body inductive or capacitive coupling, etc.

[0064] Accordingly, the scope of the invention should not be restricted to the specific exemplary embodiments disclosed herein, and all modifications that are readily suggested to those of ordinary skill in the art should be included within the spirit and purview of this application and scope of the appended claims.

What is claimed is:

1. A wireless system, comprising:

a first wireless receiver coupled to a first data sink; and

a second wireless receiver coupled to a second data sink,

wherein said first and second data sinks have no physical or electrical connection between them, and said first and second wireless receivers are operable to reduce a differential latency between data received by said first wireless receiver and data received by said second wireless receiver.

2. The wireless system of claim **1** wherein said first and second data sinks comprise first and second earphones adapted to fit into first and second ears of a user.

3. The wireless system of claim **1** wherein said first and second data sinks comprise first and second circum-aural headphones adapted to fit over first and second ears of a user.

4. The wireless system of claim **1** wherein said first and second data sinks comprise first and second speakers.

5. The wireless system of claim **1** wherein said first wireless receiver is configured to receive a data modulated carrier signal from a single wireless transmitter.

6. The wireless system of claim **5** wherein said second wireless receiver is also configured to receive the data modulated carrier signal from said single wireless transmitter.

7. The wireless system of claim **1** wherein:

said first wireless receiver is configured to receive a first data modulated carrier signal from a first wireless transmitter over a first single-access wireless link; and

said second wireless receiver is configured to receive a second data modulated signal from a second wireless transmitter over a second single-access wireless link.

8. The wireless system of claim **7** wherein the data modulated onto the first data modulated carrier signal is the same as the data modulated onto the second data modulated carrier signal.

9. The wireless system of claim **7** wherein the data modulated onto the first data modulated carrier signal is different from the data modulated onto the second data modulated carrier signal.

10. The wireless system of claim **1**, further comprising a wireless transmitter operable to transmit at least a subset of data received by said first one of said first and second wireless receivers to a second one of said first and second wireless receivers.

11. The wireless system of claim **10** wherein said first one of said first and second wireless receivers is adapted to receive data signals according to a first wireless technology and said second one of said first and second wireless receivers is adapted to receive data signals according to a second wireless technology.

12. The wireless system of claim **1** further comprising:

a wireless transmitter coupled to one of said first and second wireless receivers; and

a data source coupled to said wireless transmitter.

13. The wireless system of claim **12** wherein said data source comprises a sensor.

14. The wireless system of claim **12** wherein said data source comprises a microphone.

15. The wireless system of claim **1** wherein at least one of said first and second wireless receivers is configured to receive data signals in accordance with the Bluetooth radio standard.

16. The wireless system of claim **1** wherein:

said first wireless receiver is configured to receive a first data modulated carrier signal carrying data exclusively for said first data sink; and

said second wireless receiver is configured to receive a second data modulated carrier signal carrying data exclusively for said second data sink.

17. The wireless system of claim **1** wherein said first and second wireless receivers are configured to receive data modulated carrier signals from a multi-access wireless transmitter over a multi-access wireless link.

18. A wireless headphone system, comprising:

a right-ear data sink having first means for wirelessly receiving a data modulated carrier signal; and

a left-ear data sink having second means for wirelessly receiving a data modulated carrier signal,

wherein said right-ear and left-ear data sinks have no physical or electrical connection between them.

19. The wireless headphone system of claim **18**, further comprising means for reducing differential latency between data received by said first means and data received by said second means.

20. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means includes the same data as the data modulated carrier signal received by the second means.

21. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means includes data that is different from the data included in the data modulated carrier signal received by the second means.

22. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means and the data modulated carrier signal received by the second means are both transmitted from a single wireless transmitter.

23. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means is transmitted from a first wireless transmitter and the data modulated carrier signal received by the second means is transmitted from a second wireless transmitter.

24. The wireless headphone system of claim **18** wherein the first means and the second means are adapted to receive data modulated carrier signals from a multi-access wireless transmitter over a multi-access wireless link.

25. The wireless headphone system of claim **18**, further comprising a wireless transmitter coupled to one of said right-ear and left ear data sinks, said wireless transmitter configured to receive data from a data source.

26. The wireless headphone system of claim **25** wherein said data source comprises a sensor.

27. The wireless headphone system of claim **25** wherein said data source comprises a microphone.

28. The wireless headphone system of claim **18** wherein at least one of said first and second means is adapted to receive a data modulated carrier signal that is compliant with the Bluetooth radio standard.

29. A wireless communication system, comprising:

a first data sink coupled to a first wireless communication means;

a second data sink coupled to a second wireless communication means; and

third wireless communication means for modulating data from a first data source onto one or more carrier signals and transmitting one or more data modulated carrier signals to at least one of said first and second wireless communication means,

wherein said first and second data sinks have no physical or electrical connection between them and at least one of said first and second wireless communication means is operable to reduce a differential latency between data provided to said first data sink and data provided to said second data sink.

30. The wireless communication system of claim **29** wherein said first wireless communication means includes wireless transmission means for wirelessly transmitting at least a subset of data received by said first wireless communication means to said second wireless communication means.

31. The wireless communication system of claim **30** wherein said at least a subset of said data transmitted by said wireless transmission means to said second wireless communication means is transmitted according to a first wireless technology and data transmitted by said third wireless communication means to said at least one of said first and second wireless transmission means is transmitted according to a second wireless technology.

32. The wireless communication system of claim **29**, further comprising:

a second data source adapted to provide data to transmission means of said first wireless communication means; and

means for receiving from said transmission means a wireless carrier signal modulated by data from said second data source.

33. The wireless communication system of claim **32** wherein said second data source comprises a sensor.

34. The wireless communication system of claim **32** wherein said second data source comprises a microphone.

35. The wireless communication system of claim **29** wherein said third communication means includes a single wireless transmitter operable to modulate data from said first data source onto a single carrier signal, and broadcast the data modulated carrier signal to said first and second wireless communication means.

36. The wireless communication system of claim **29** wherein said third communication means comprises:

a first wireless transmitter operable to transmit a first carrier signal modulated by a first subset of data provided by said first data source to said first wireless communication means; and

a second wireless transmitter operable to transmit a second carrier signal modulated by a second subset of data provided by said first data source to said second wireless communication means.

37. The wireless communication system of claim **29** wherein said third wireless communication means comprises first and second wireless transmitters that are both operable to modulate data for reception by both said first and second communication means onto a single carrier signal.

38. The wireless communication system of claim **29** wherein said third wireless communication means comprises first and second wireless transmitters operable to modulate data for reception by said first and second communication means, respectively, onto first and second carrier signals.

39. The wireless communication system of claim **29** wherein:

said first data sink comprises a first earphone adapted to fit into a first ear of a user; and

said second data sink comprises a second earphone adapted to fit into a second ear of the user.

40. The wireless communication system of claim **29** wherein:

said first data sink comprises a first circum-aural headphone adapted to fit over a first ear of a user; and

said second data sink comprises a second circum-aural headphone adapted to fit over a second ear of the user.

41. The wireless communication system of claim **29** wherein said first, second and third wireless communication means comprises multi-access wireless communication means that communicate over a multi-access wireless link.

42. The wireless communication system of claim **29** wherein at least one of said first and second wireless communication means is adapted to receive a data modulated carrier signal in accordance with the Bluetooth radio standard.

* * * * *

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(12) **United States Patent**
Huddart

(10) **Patent No.: US 7,627,289 B2**
(45) **Date of Patent: Dec. 1, 2009**

(54) **WIRELESS STEREO HEADSET**

(75) Inventor: **David Huddart**, Westbury-on-Trym (GB)

(73) Assignee: **Plantronics, Inc.**, Santa Cruz, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 517 days.

(21) Appl. No.: **11/317,984**

(22) Filed: **Dec. 23, 2005**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04B 7/00 (2006.01)

(52) **U.S. Cl.** **455/41.2**; 455/575.2; 455/343.1; 455/41.3

(58) **Field of Classification Search** 455/575.2, 455/343.1–343.6, 41.1–41.3; 381/380, 376, 381/367; 379/428.02
See application file for complete search history.

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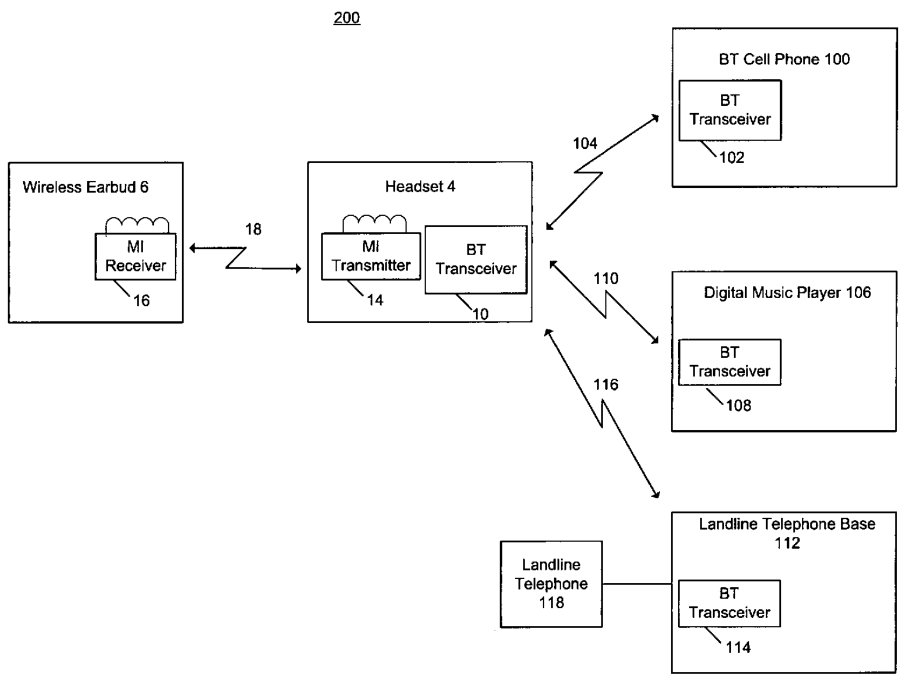
Primary Examiner—Lana N Le
(74) *Attorney, Agent, or Firm*—Intellectual Property Law Office of Thomas Chuang

(57) **ABSTRACT**

Systems and methods for a wireless stereo headset are disclosed. The system generally includes a first headset component and a second headset component. Both the first headset component and the second headset component may be wireless devices.

20 Claims, 8 Drawing Sheets



 APPLE 1005

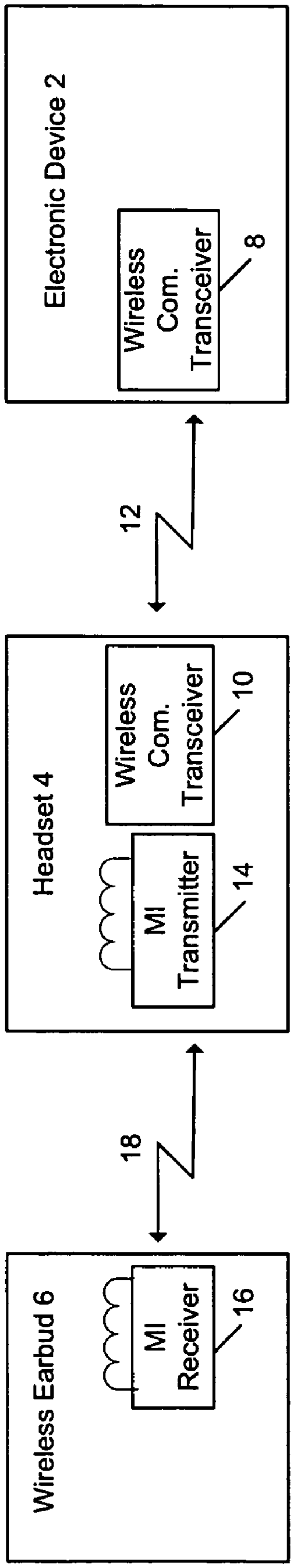

Electronic Device 2
Wireless Com. Transceiver
8
12
Headset 4
Wireless Com. Transceiver
10
MI Transmitter
14
18
Wireless Earbud 6
MI Receiver
16

FIG. 1

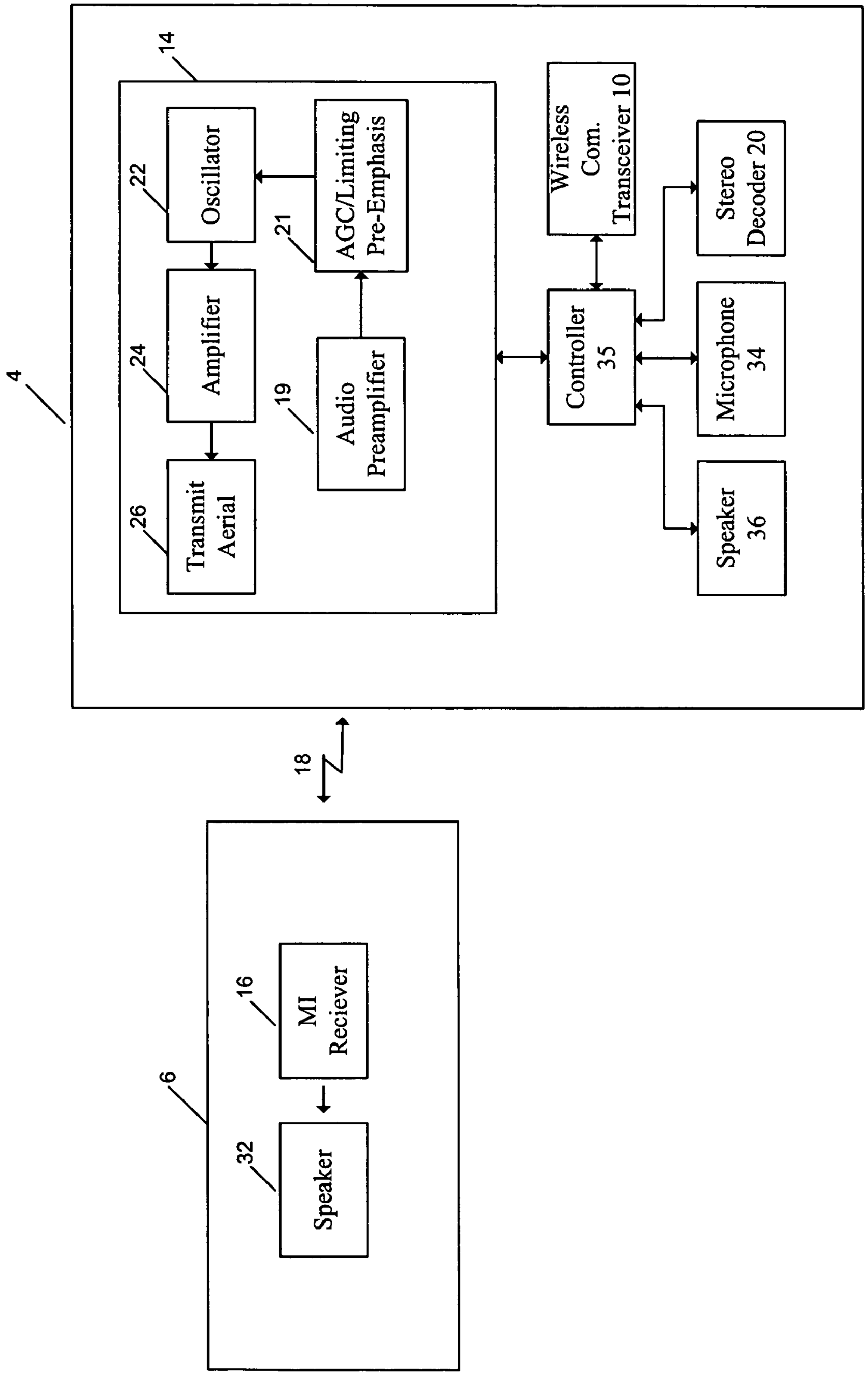

4
14
22
Oscillator
21
AGC/Limiting
Pre-Emphasis
24
Amplifier
19
Audio
Preamplifier
26
Transmit
Aerial
Wireless
Com.
Transceiver 10
Controller
35
Stereo
Decoder 20
Microphone
34
Speaker
36
18
6
16
MI
Reciever
32
Speaker

FIG. 2

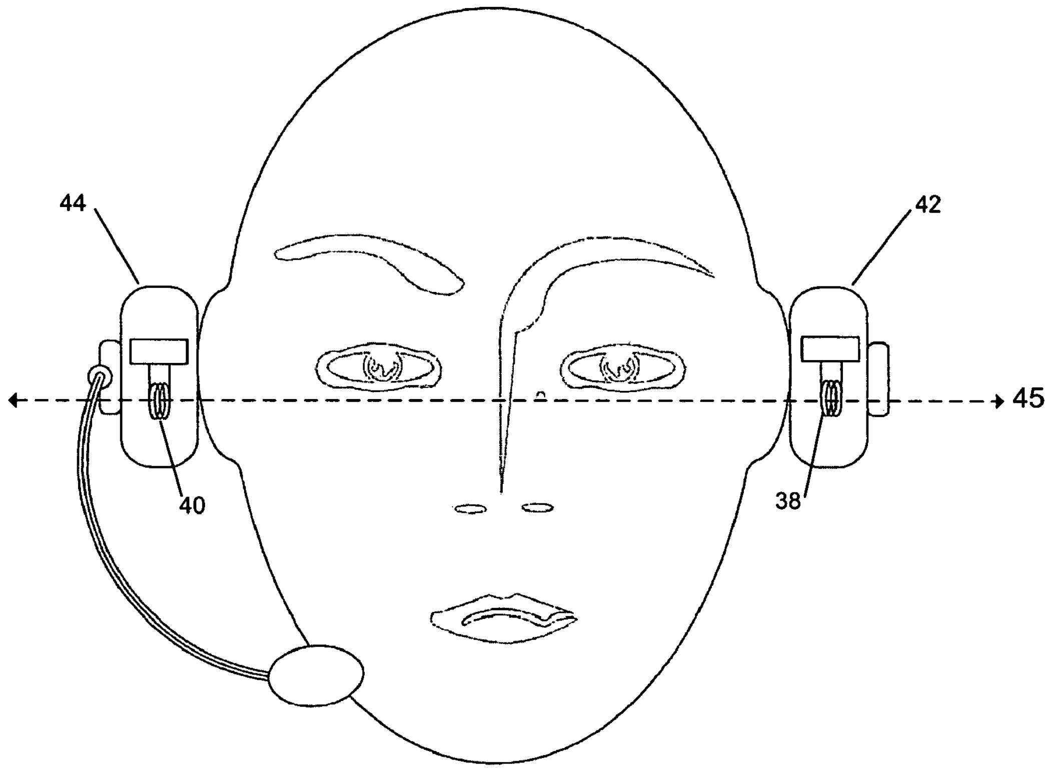


FIG. 3

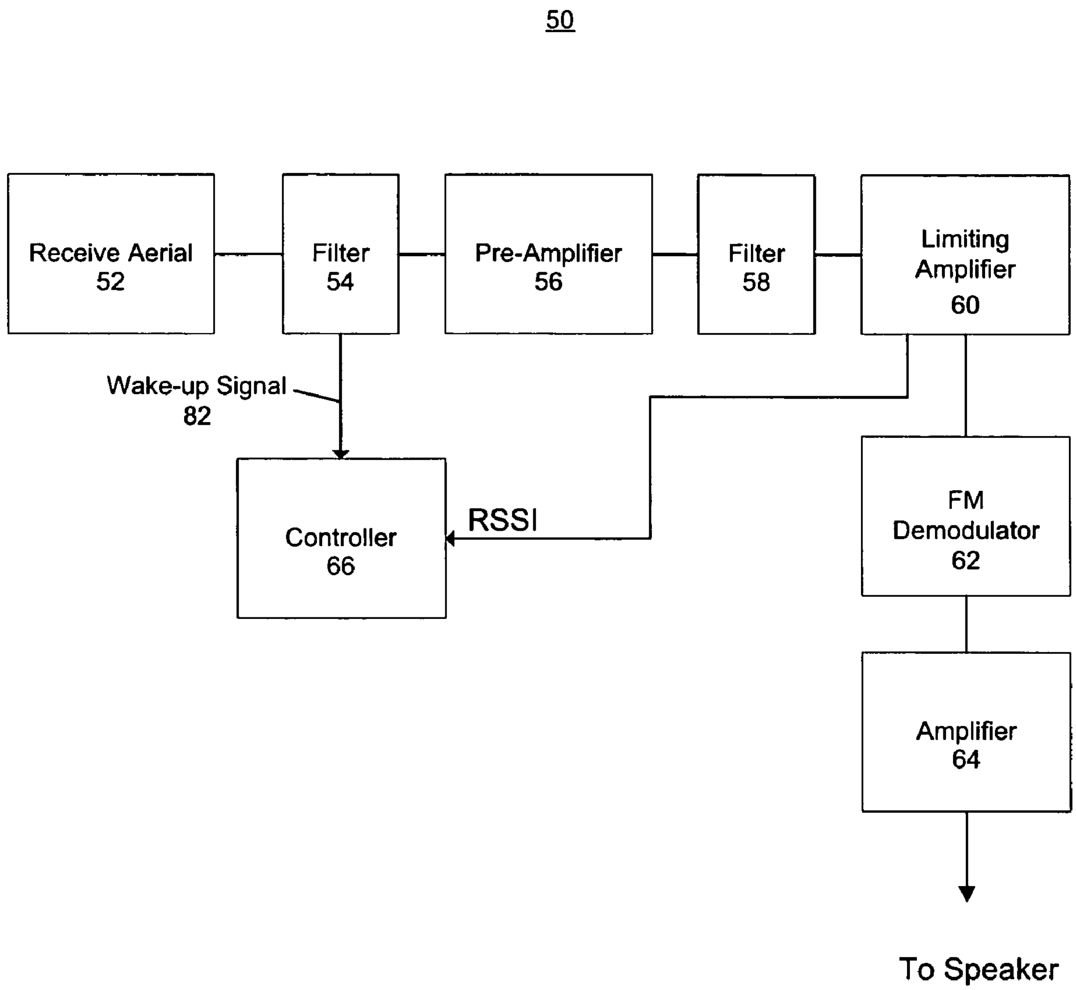

50
Receive Aerial 52
Filter 54
Pre-Amplifier 56
Filter 58
Limiting Amplifier 60
Wake-up Signal 82
Controller 66
RSSI
FM Demodulator 62
Amplifier 64
To Speaker

FIG. 4

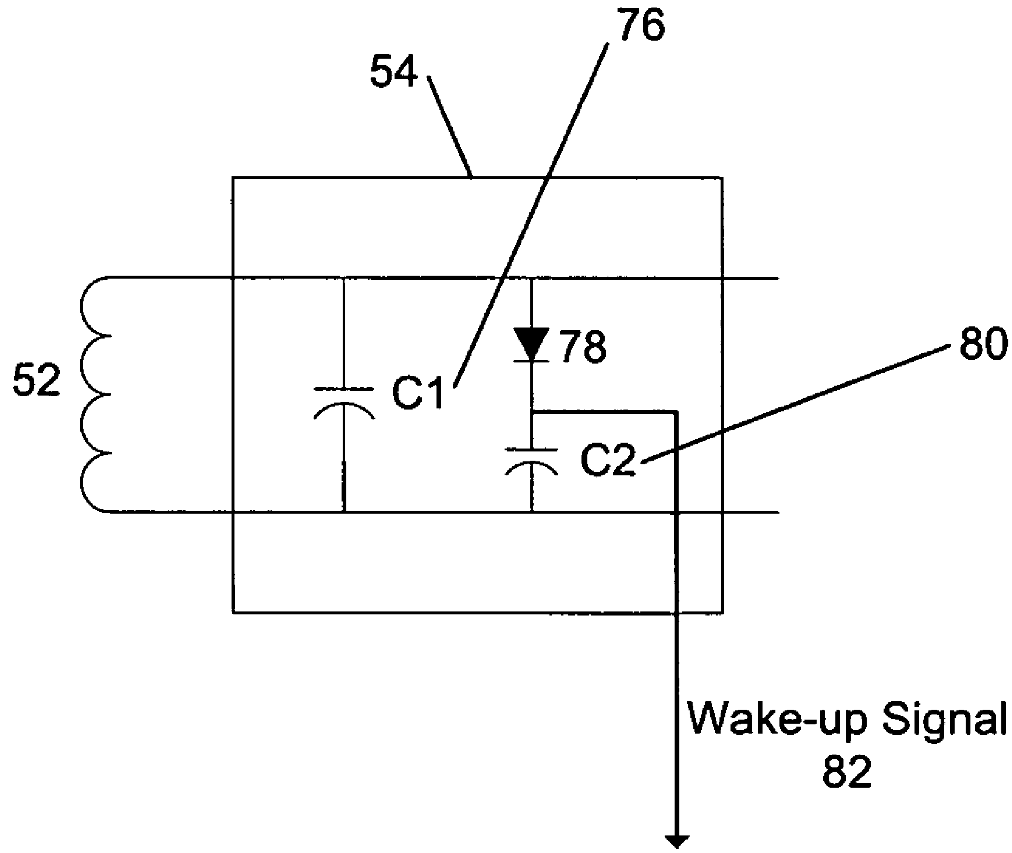


FIG. 5

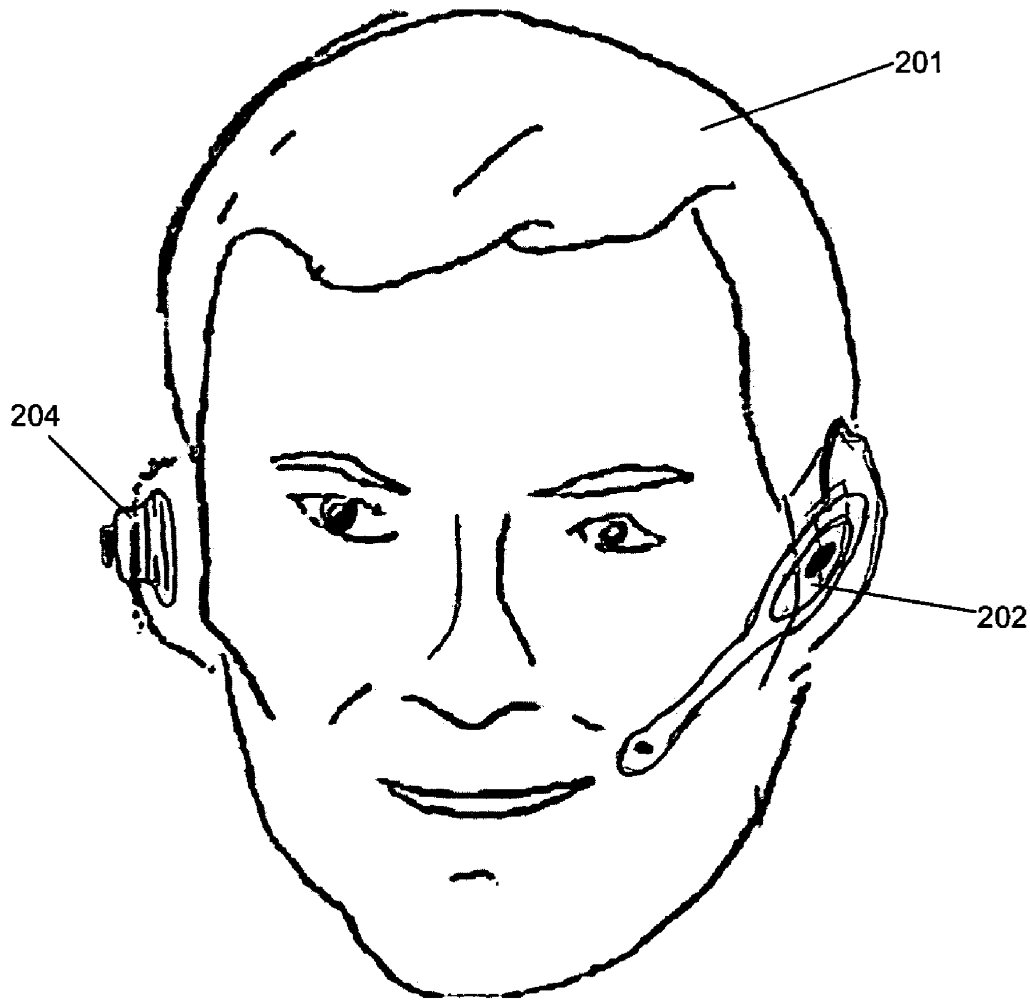


FIG. 6

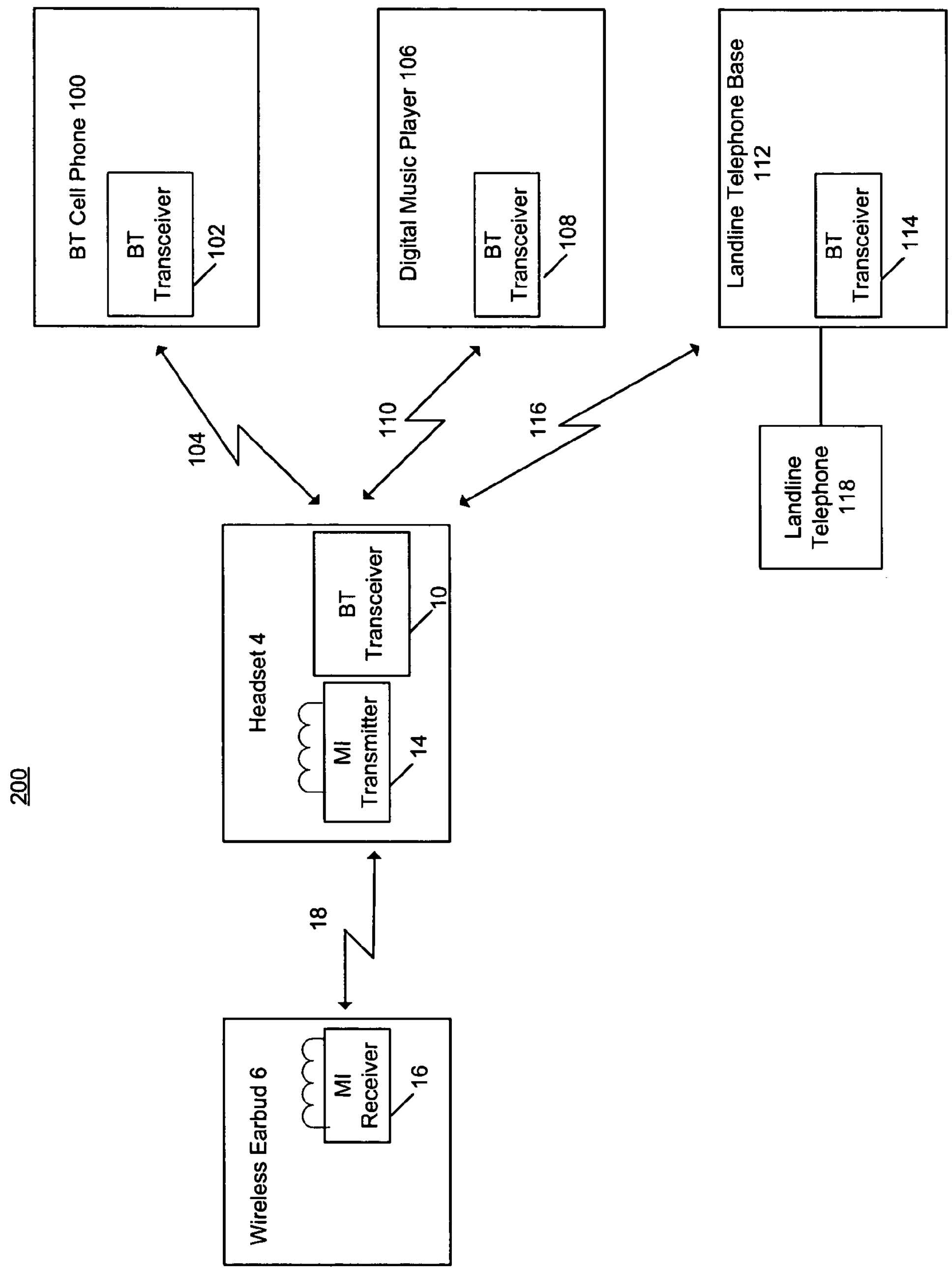

BT Cell Phone 100
BT Transceiver
102
Digital Music Player 106
BT Transceiver
108
Landline Telephone Base 112
BT Transceiver
114
104
110
116
Landline Telephone 118
Headset 4
BT Transceiver
10
MI Transmitter
14
200
18
Wireless Earbud 6
MI Receiver
16

FIG. 7

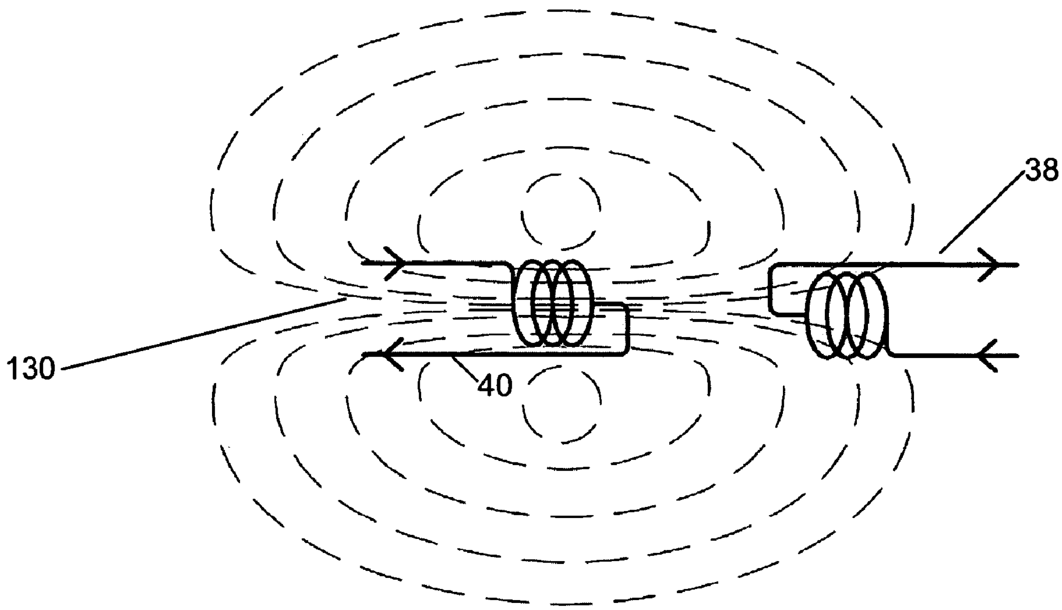


FIG. 8

WIRELESS STEREO HEADSET

BACKGROUND OF THE INVENTION

Conventional wireless communication headsets are monaural. As a result, many headsets utilize an "over the ear" configuration not requiring the use of a headband. However, there are certain usage scenarios in which the user of a wireless communication headset may wish to listen to a stereo signal using both ears. Such usage scenarios are expected to increase with the availability of a variety of electronic devices and multi-function devices. Such devices include cellular telephones, digital music players, personal digital assistants, and devices combining one or more of these devices into a single integrated device.

Conventional prior art stereo headsets use a headband to support the two speakers outputting the stereo channels. A headband solution implements stereo operation by using the headband to carry the electrical signals from one side of the head to the other with an electrical wire. Another prior art solution utilizes wires to conduct the electrical signals without the headband. For example, a wired earbud may extend from a wireless monaural headset.

However, the use of a headband or wires is not desired in a variety of situations. For example, users may have a personal preference against wearing a headband. The user may not wish to have any wires attached to any part of the headset or worn about the body. In certain situations, the user will wish to have a headset capable of stereo operation. However, the user also wishes to have the option of wearing only a monaural earpiece during monaural operation such as during a telephone call. The user is then required to use two different headsets—a monaural headset for telephone operation and a wireless stereo headset for stereo listening applications.

As a result, there is a need for improved methods and apparatuses for stereo headsets.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements.

FIG. **1** illustrates a system view of a wireless stereo headset system in one example of the invention.

FIG. **2** illustrates a simplified block diagram of a headset and wireless earbud in one example of the invention.

FIG. **3** illustrates a magnetic induction transmitter in a headset and a magnetic induction receiver in a wireless earbud.

FIG. **4** illustrates simplified block diagram of a receive circuit in an earbud in one example of the invention.

FIG. **5** illustrates a simplified receiver circuit filter in one example of the invention.

FIG. **6** illustrates a wireless stereo headset system worn by a user in one example of the invention.

FIG. **7** illustrates a system view of a further example of a wireless stereo headset system in one example of the invention.

FIG. **8** illustrates coupling between a magnetic induction transmitter and a magnetic induction receiver.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Methods and apparatuses for wireless stereo headsets are disclosed. The following description is presented to enable any person skilled in the art to make and use the invention. Descriptions of specific embodiments and applications are provided only as examples and various modifications will be readily apparent to those skilled in the art. The general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, the present invention is to be accorded the widest scope encompassing numerous alternatives, modifications and equivalents consistent with the principles and features disclosed herein. For purpose of clarity, details relating to technical material that is known in the technical fields related to the invention have not been described in detail so as not to unnecessarily obscure the present invention.

Generally, this description describes a method and apparatus for a wireless stereo headset system having a headset component and a wireless earbud component. In one example, the wireless headset system has a stereo mode utilizing a wireless earbud to output one channel of a stereo signal. The invention may be utilized in conjunction with a variety of electronic devices, including cell phones, PDAs, and MP3 or other digital format players. While the present invention is not necessarily limited to such devices, various aspects of the invention may be appreciated through a discussion of various examples using this context.

According to an example of the present invention, a wireless headset includes a magnetic induction (MI) transmitter such that a wireless link may be formed with a wireless earbud containing a magnetic induction receiver. One channel of a stereo signal is transmitted from the headset to the earbud over the wireless link to enable a user to listen to the stereo signal. In one example mode of operation, the wireless headset is Bluetooth enabled and communicates with a Bluetooth enabled cellular telephone. The headset can be used in a monaural mode and switched seamlessly between monaural and stereo operational modes. For example, Bluetooth Multipoint mode may be used.

According to an example of the invention, a stereo headset system includes a first wireless component having a first speaker, a microphone, a first wireless communication module, and a second wireless communication module. The stereo headset system includes a second wireless component having a second speaker and a third wireless communication module for receiving an audio signal from the second wireless communication module during stereo mode operation.

According an example of the invention, a headset system includes an electronic device capable of outputting a monaural or a stereo audio signal, a first headset component for receiving the monaural or the stereo signal from the electronic device, and a second headset component capable of wireless communications with the first headset component. The second headset component receives the stereo signal or a component of the stereo signal from the first headset component.

FIG. **1** illustrates a system view of a wireless stereo headset system in use in one example of the invention. A headset **4** is in proximity to an electronic device **2**. In one example of the invention, both headset **4** and electronic device **2** have wireless communication functionality to implement wireless communications there between over a wireless communication link **12**. Electronic device **2** includes a wireless communication transceiver **8** and headset **4** includes a wireless communication transceiver **10**. In a further example, headset **4** and electronic device **2** may communicate via a wired link. Although only one electronic device **2** is illustrated, headset **4** may communicate with and switch between multiple electronic devices. Electronic device **2**, for example, may be any electronic device capable of transmitting data such as voice or text data to headset **4**. Examples of electronic device **2** include, but are not limited to cellular telephones, digital

music players, personal digital assistants, or combinations thereof. A particular electronic device **2** may output only a monaural signal or only a stereo signal. In a further example, a particular electronic device **2** may output both a monaural signal and a stereo signal, dependent upon the device mode of operation.

When stereo listening operation is desired by a user, a wireless earbud **6** is used in conjunction with headset **4**. Both headset **4** and wireless earbud **6** have wireless communication functionality to form a wireless communication link **18**. In one example of the invention, wireless communication link **18** is implemented using magnetic induction. Headset **4** includes a magnetic induction transmitter **14** and wireless earbud **6** includes a magnetic induction receiver **16**. Although reference is made to a wireless earbud herein, any wireless device capable of receiving and outputting an audio signal into a user's ear may be utilized including, for example, over-the-ear or in-the-ear devices.

In one example of the invention, a magnetic induction wireless communication link is established between headset **4** and wireless earbud **6**. Magnetic induction provides short range wireless communication at low power and cost while providing good audio signal quality. Magnetic induction allows the use of very simple analogue RF technologies to generate and receive signals. In one example, analogue FM modulation with carrier frequencies in the range 1-15 MHz is used. In further examples of the invention, AM modulation may be used, as well as various forms of digital modulation.

The use of magnetic induction is particularly advantageous. The magnetic field strength drops as a 4^{th} power of distance, resulting in a limited range. Interference between two or more users will be limited by the 4^{th} power field strength characteristic hence a single operating carrier channel will suffice. Use of FM modulation also helps due to the capture effect. Magnetic induction communication systems are discussed, for example, in U.S. Pat. No. 6,134,420 entitled "Vector Measuring Aerial Arrays for Magnetic Induction Communication Systems" and U.S. Pat. No. 6,061,030 entitled "Aerial Arrays for Magnetic Induction Communication Systems Having Limited Power Supplies", which are assigned to the present applicant Plantronics, Inc. and hereby incorporated by reference for all purposes.

The range of transmission required between the magnetic induction transmitter and magnetic induction receiver is small and is approximately between 200 and 300 mm depending on the size of the user. Due to the short range required in this application, low power operation is possible. In operation, wireless earbud **6** may automatically activate when brought in range of headset **4**.

Magnetic induction generally requires the transmit and receive coils to be aligned, preferably axially. In this application alignment is automatic since the user's ears are normally axially aligned either side of the head. As a result, when the headset **4** and wireless earbud **6** are worn, the transmit and receive coils are automatically axially aligned. In further examples of the invention, other methods of wireless communication may be used to establish wireless communication link **18** between headset **4** and wireless earbud **6**. For example, wireless earbud **6** may be Bluetooth enabled to communicate with either headset **4** or electronic device **2**.

FIG. **2** illustrates a more detailed view of the headset **4** and wireless earbud **6** shown in FIG. **1**. Headset **4** may include a headset controller **35** that comprises a processor, memory and software to implement functionality as described herein. The headset controller **35** receives input from the headset user interface and manages an audio signal detected by microphone **34**, and manages an audio signal sent to an audio transducer such as speaker **36**. The headset controller **35** further interacts with wireless communication transceiver **10** (also referred to herein as a wireless communication module) to transmit and receive signals between the headset **4** and electronic device **2** employing wireless communication transceiver **8**. Controller **35** further interacts with magnetic induction transmitter **14** and stereo decoder **20** to transmit audio from headset **4** to wireless earbud **6**. In a further example, the wireless communication transceiver **10** may include a controller which controls one or more operations of the headset **4**.

Although one example is discussed in reference to a headset **4**, other mobile communication devices may be utilized instead of a headset. In one example of the invention, headset **4** is an over-the-ear headset. Headset **4** may be boomless, as the particular category of headset used may vary. Headset **4** includes a wireless communication transceiver **10** for communication with a wireless communication transceiver **8** located in the electronic device **2**.

Referring again to FIG. **1**, the wireless communication transceivers **8** and **10** can be in the form of a digital wireless transceiver for bi-directional communication. For example, the wireless communication transceivers **8** and **10** can be a transceiver used in known wireless networking devices that operate under the standard of Bluetooth.

Bluetooth is a radio-frequency protocol which allows electronic devices to connect to one another over short-range radio links. Bluetooth devices operate in the ISM (industrial, scientific, medical) band at about 2.4 to 2.5 GHz, and have a range limited to about 10 meters. Spread spectrum frequency hopping limits interference from other devices using the ISM bandwidth. The Bluetooth specification, version 2.0, is hereby incorporated by reference.

A prescribed interface such as Host Control Interface (HCI) is defined between each Bluetooth module. Message packets associated with the HCI are communicated between the Bluetooth modules. Control commands, result information of the control commands, user data information, and other information are also communicated between Bluetooth modules. In operation, electronic device **2** is activated and polls for possible headset devices. Activation and polling may be performed in a manner similar to the Bluetooth Device Discovery Procedure as described in the Bluetooth Specification. A link establishment protocol is then initiated between headset **4** and electronic device **2**. The BT Advanced Audio Distribution Profile (A2DP) is used to transmit stereo audio from electronic device **2** to headset **4**. A2DP utilizes Audio/Video Control Transport Protocol (AVCTP) for command response messaging, including for example volume control and track selection. A2DP utilizes Audio/Video Distribution Transport Protocol (AVDTP) for transport of audio/video streams.

The wireless communication transceivers **8** and **10** may also, for example, operate under other wireless communication protocols such as DECT or the 802.11a, 802.11b, or related standards. Wireless communication transceivers **8** and **10** may transmit voice, data, or voice and data communications. Wireless communication transceivers **8** and **10** may be configured with a variety of protocols, including a Bluetooth hands-free protocol. Other protocols include, for example, service discovery application, file transfer protocol, and general access profile.

Headset **4** also includes typical components found in a communication headset. For example, headset **4** includes a speaker **36**, a microphone **34**, a user interface, and status indicator. The user interface may include a multifunction power, volume, stereo/monaural, mute, and select button or buttons. Other user interfaces may be included on the headset,

such as a link active/end interface. It will be appreciated that numerous other configurations exist for the user interface. The particular button or buttons and their locations are not critical to the present invention.

The headset **4** includes a boom with the microphone **34** installed at the lower end of the boom. The headset **4** may include a loop attachment to be worn over the user's ear. Alternatively, the main housing of the headset may be in the shape of a loop to be worn behind a user's ear. The headset **4** further includes a power source such as a rechargeable battery installed within the housing to provide power to the various components of the receiver. User speech detected by microphone **34** is transmitted from the headset **4** to electronic device **2** with wireless communication transceiver **10**.

Headset **4** and wireless earbud **6** include internal components which are described below in reference to FIGS. **2**-**5**. Referring again to FIG. **2**, there is shown a block diagram of a MI communication system that uses magnetic induction fields as a communication link. The MI communication system includes magnetic induction transmitter **14** in a headset **4** and a magnetic induction receiver **16** in a wireless earbud **6**. The magnetic induction transmitter **14** includes an audio preamplifier **19**, AGC/Limiting pre-emphasis function **21**, oscillator **22**, amplifier **24**, and transmit aerial **26**. Wireless earbud **6** includes a magnetic induction receiver **16** and speaker **32**. Wireless earbud **6** also includes a power source such as a rechargeable battery and a controller comprising a processor, memory and software to implement functionality as described herein.

In the magnetic induction transmitter **14**, the audio preamplifier **19** outputs an amplified audio signal to the AGC/Limiting pre-emphasis function **21**, which performs frequency and amplitude shaping of the audio signal. In one example, oscillator **22** is a voltage controlled oscillator. The transmit aerial **26** is typically a small MI aerial having a ferrite core to achieve transmission efficiency. Alternatively, an air core may be used depending upon the operating frequency and desired form factor. The magnetic field generated by transmit aerial **26** provides a carrier that can be modulated by an information signal from, for example, a stereo decoder **20**.

Stereo decoder **20** decodes a stereo signal received on wireless communication transceiver **10** into a left audio channel and a right audio channel. Either the left audio channel or right audio channel is sent to the magnetic induction receiver **16** using magnetic induction transmitter **14**. The received signal is then output by speaker **32** at earbud **6**. The left or right audio channel not transmitted is output at the headset **4** by speaker **36**. In one configuration, the user may select whether the earbud receives the left or right channel and whether the headset receives the left or right channel, enabling the user to decide which ear has the mono signal and microphone boom. In a further example of the invention, a stereo decoder may be located at the wireless earbud **6** for decoding a stereo signal received at wireless earbud **6**.

An information signal modulated on a MI carrier and transmitted by a distant unit is received via a receive aerial forming part of the magnetic induction receiver **16**. A voltage is induced in the receive aerial when it experiences a changing flux. The change may be produced by varying the magnitude or the direction of the incident field. Alternating the magnitude of a flux in a sinusoidal manner induces a sinusoidal voltage in the receive aerial. The receive aerial may also have a ferrite core to achieve efficient reception of the information signal. After the signal is received by the receive aerial it is further processed by the magnetic induction receiver prior to output by speaker **32**.

A practical implementation within a headset and wireless earbud are also influenced by the headset and earbud geometry.

Transmit and receive aerials utilize air-cored coils in one example of the invention. These air-cored coils may be pancake shaped. Transmit and receive aerials will operate at 13.56 MHz, although frequency ranges between 1 MHz and 20 MHz may be employed. 13.56 MHz is an internationally approved ISM band for use with plasma cutting equipment and wireless MI linked identification tags. The air-cored coils may be formed of conductive wire, self-adhesive foil, or tracks on a printed circuit board. The shape of the aerial may be altered to conform to the physical shape of the package. The loop may be formed at the time of installation.

Referring to FIG. **3**, there is shown a front view of one embodiment of a horizontal field configuration of aerials in accordance with the present invention. The configuration includes an air core loop aerial **40** in a headset **44** and an air core loop aerial **38** in an earbud **42**. The loop aerial **40** and loop aerial **38** are axially aligned along an axis **45** to provide maximum coupling between the aerials. Due to the alignment of a user's ears, axial alignment of the loop aerial **40** and loop aerial **38** is easily achieved to provide maximum coupling when the headset and earbud are worn. The axially aligned loop aerial **40** and loop aerial **38** may be rotated about axis **45** without affecting coupling, allowing for flexible wearing of the earbud and headset. In a further example, loop aerial **40** and loop aerial **38** may be rotated by ninety degrees (i.e., radially aligned) or tilted to direct the magnetic fields, and sufficient coupling will exist. Referring to FIG. **8**, the loop aerial **40** generates magnetic flux lines defined by a magnetic flux vector **130** ("H") that extends through the center of the loop aerial **40**. As shown in FIG. **8**, the magnetic flux lines generated by the loop aerial **40** close on themselves and link with loop aerial **38** to induce a signal in loop aerial **38**.

Referring to FIG. **4**, there is shown a block diagram illustrating a receive circuit **50** for a magnetic induction receiver in accordance with one example. The receive circuit **50** includes a receive aerial **52**, filter **54**, pre-amplifier **56**, filter **58**, limiting amplifier **60**, FM demodulator **62**, amplifier **64**, and controller **66**. Filter **54** removes unwanted interfering signals detected by the receive aerial **52**, including WiFi signals or radio signals. For example, filter **54** may be a capacitor across the output of the receive aerial **52**. The pre-amplifier **56** is a conventional preamplifier.

One advantage of the invention is that the wireless earbud **6** does not require an on or off user interface to activate or deactivate the wireless earbud. If wireless earbud **6** is brought within close range to the magnetic induction transmitter, a voltage induced in the receive aerial **52** generates an activate/wake up signal which is passed to controller **66**. To power the earbud up, it would only be necessary to touch the earbud to the headset or bring the earbud within range of less than approximately **3** inches. As the magnetic field strength is so dependent on separation distance, very small separation distances result in very high coupling. The receive signal at very small distances would be sufficient to turn on a silicon diode rectifier or a bipolar junction transistor (>0.7V) and so power up the earbud from a zero power state. The voltage generated may be in the magnitude of volts. Controller **66** then activates the wireless earbud **6**. In one example, the activate current is passed through a diode in filter **54**. Once powered, the carrier strength is monitored and once it falls below a predetermined threshold for a pre determined period, the earbud powers off again.

Another advantage of the invention is that the wireless earbud **6** may power down or go into "sleep mode" automati-

cally to conserve battery power upon loss of its MI carrier for a period of time. The controller **66** receives and monitors a receiver signal strength indicator (RSSI) associated with the transmission of an audio signal from the headset to the wireless earbud. If the RSSI drops below a predetermined threshold level, the controller **66** places the wireless earbud **6** in sleep modes or initiate a timer after which a predetermined time expires activate sleep mode. In one example, the RSSI signal is output from limiting amplifier **60** to controller **66**.

Referring to FIG. **5**, there is shown a more detailed view of filter **54** from FIG. **4**. A capacitor C**1** **76** is located across the output of a receive aerial **52** creating a tuned circuit and hence filtering interference in the receive signal. A diode **78** and capacitor C**2** **80** are in parallel to capacitor C**1** **76** to rectify large receive signals and hence provide a DC signal **82** that is output to controller **66**. This signal is used to wake-up the controller from a sleep, or low power state.

FIG. **6** illustrates a wireless stereo headset worn by a user **201** in an example of the invention. An over-the-ear headset **202** is capable of monaural telephone communications or stereo listening. As shown in FIG. **6**, headset **202** is shown in a stereo listening mode with a wireless earbud **204** outputting one channel of the stereo signal.

FIG. **7** illustrates a system **200** of a further example of the present invention. Although FIG. **7** illustrates a headset **4** used with three possible host electronic devices, fewer or greater electronic devices may be used.

A headset **4** is in proximity to a Bluetooth enabled cellular telephone **100**, digital music player **106**, and landline telephone base **112**. Headset **4** includes a Bluetooth transceiver **10** capable of communication with Bluetooth enabled cellular telephone **100**, digital music player **106**, and landline telephone base **112**. Landline telephone base **112** is coupled to a landline telephone **118**. Although system **200** is illustrated using Bluetooth between headset **4** and cellular telephone **100**, digital music player **106**, and landline telephone base **112**, other wireless communication standards may be used in further examples, including IEEE 802.11.

Bluetooth enabled cellular telephone **100** includes a Bluetooth transceiver **102** for communication with headset **4** over a wireless communication link **104**. Digital music player **106** includes a Bluetooth transceiver **108** for communication with headset **4** over a wireless communication link **110**. Landline telephone base **112** includes a Bluetooth transceiver **114** for communication with headset **4** over a wireless communication link **116**. A headset **4** user may switch between cellular telephone **100**, digital music player **106**, and landline telephone base **112**.

When stereo listening operation is desired by a user, a wireless earbud **6** is used in conjunction with headset **4**. Both headset **4** and wireless earbud **6** have wireless communication functionality to form a wireless communication link **18**. In one example of the invention, wireless communication link **18** is implemented using magnetic induction. Headset **4** includes a magnetic induction transmitter **14** and wireless earbud **6** includes a magnetic induction receiver **16**.

The present invention allows for a variety of usage modes. The headset may be used as a conventional telecommunications headset without the earbud when the user merely wishes to receive and make calls on an electronic device such as a cell phone **100** or landline telephone **118**.

The headset **4** may be used in conjunction with the earbud **6** for stereo listening from a cellular telephone **100**, digital music player **106**, or other electronic device. In operation, the headset may be switched from stereo to monaural mode when an incoming call is received on Bluetooth cellular telephone **100** or landline telephone **118**. When switching between

modes of operation, the user either removes or inserts the wireless earbud. For example, a user listening to music from a digital music player **106** will have the music interrupted when an incoming call is received on cellular telephone **100**. The user may then remove the wireless earbud **6**. Switching may be implemented automatically by the headset controller at headset **4** upon signaling by the cellular telephone or digital music player.

In a further example of the invention, wireless earbud **6** may receive a stereo audio signal or a component of a stereo audio signal from an electronic device **2** rather than from headset **4**. In such an example, both wireless earbud **6** and headset **4** have a wireless communication link (e.g., Bluetooth or IEEE 802.11) with the electronic device. Both the headset **4** and wireless earbud **6** output one channel of the stereo signal. In one example, the BT A2DP profile is used to implement a proprietary system for time stamping, buffering, and synchronizing the audio stream.

The headset system described herein may have additional features. For example, wireless earbud **6** may employ a sleep function. If the headset **4** is not within range for a predetermined time, wireless earbud **6** is powered down. A push button user interface powers the wireless earbud **6** up or, after a prolonged depression, powers down.

The headset system may further include a charger/carrier, such as a pocket charger, including a small plastic storage case for storing the headset **4** and wireless earbud **6** for protection and charging. The pocket charger includes a battery and charger circuit for charging both the headset battery and wireless earbud battery when inserted into the pocket charger/carrier. The use of a pocket charger/carrier provides a convenient mechanism by which the earbud **6**, having a relatively smaller capacity battery due to its limited size, may be recharged in the absence of a primary charger.

In a further example, the charger/carrier utilizes a charging coil to provide charging current to the wireless earbud battery **84** via receive aerial **52** shown in FIG. **4**. The earbud advantageously does not require charging contacts on its small exterior surface when charging is performed with inductive charging. In this example, the single receive aerial **52** functions multiply to receive charging power for battery **84**, generate a wake up signal **82**, or receive an audio signal carrier. An on/off user interface and charging contacts are therefore not required on the wireless earbud. In a further example, the charging coil of the charger/carrier is used to charge the battery of the headset as well. Inductive charging systems are discussed in the patent application "Inductive Charging System", application Ser. No. 10/882,961, filed Jul. 1, 2004 and assigned to the present applicant Plantronics, Inc., which is hereby incorporated by reference.

The headset system may further include a primary charger to which the pocket charger may be removably attached. The primary charger may be a cable or docking facility connecting the pocket charger/carrier to a wall outlet or primary batter such as a car battery, allowing the headset battery, wireless earbud battery, and the storage case battery to be charged using the wall outlet or primary battery.

The various examples described above are provided by way of illustration only and should not be construed to limit the invention. Based on the above discussion and illustrations, those skilled in the art will readily recognize that various modifications and changes may be made to the present invention without strictly following the exemplary embodiments and applications illustrated and described herein. Such changes may include, but are not necessarily limited to: the wireless communication technology or standards to perform the link between the headset and wireless earbud; compo-

nents of the magnetic induction transmitter and receiver circuits; the wireless communication technology or standards to perform the link between the electronic device and the headset; components of the magnetic induction system, including the type and orientation of transmitter and receiver coils; types of electronic devices; number, placement, and functions performed by the user interface. Furthermore, the shapes and sizes of the illustrated headset and wireless earbud housing and components may be altered. Such modifications and changes do not depart from the true spirit and scope of the present invention that is set forth in the following claims.

While the exemplary embodiments of the present invention are described and illustrated herein, it will be appreciated that they are merely illustrative and that modifications can be made to these embodiments without departing from the spirit and scope of the invention. Thus, the scope of the invention is intended to be defined only in terms of the following claims as may be amended, with each claim being expressly incorporated into this Description of Specific Embodiments as an embodiment of the invention.

What is claimed is:

1. A stereo headset system comprising:

a first wireless component comprising:

a first speaker;

a microphone;

a first wireless communication module;

a first wireless component housing;

a second wireless communication module comprising a magnetic induction transmitter, the magnetic induction transmitter comprising a transmit loop aerial disposed within the first wireless component housing at a first orientation; and

a second wireless component comprising:

a second wireless component housing;

a second speaker; and

a third wireless communication module comprising a magnetic induction receiver for receiving an audio signal from the second wireless communication module during stereo mode operation, the magnetic induction receiver comprising a receive loop aerial disposed within the second wireless component housing at a second orientation matching the first orientation, wherein the transmit loop aerial and receive loop aerial are axially aligned during stereo mode operation.

2. The stereo headset system of claim **1**, wherein the first wireless communication module utilizes the Bluetooth standard.

3. The stereo headset system of claim **1**, wherein the first wireless communication module utilizes the IEEE 802.11 standard.

4. The stereo headset system of claim **1**, wherein the magnetic induction transmitter and the magnetic induction receiver operate at a frequency range between 1 MHz and 20 MHz.

5. The stereo headset system of claim **4**, wherein the magnetic induction transmitter and the magnetic induction receiver operate at a frequency of 13.56 MHz.

6. The stereo headset system of claim **1**, wherein the magnetic induction transmitter and the magnetic induction receiver utilize air-cored coils.

7. The stereo headset system of claim **1**, wherein the second wireless component is activated when the first wireless component is brought within three inches or contacted with the second wireless component.

8. The stereo headset system of claim **1**, wherein the second wireless component further comprises a battery and the magnetic induction receiver receives charging current for the battery from an inductive charger.

9. A headset system comprising:

an electronic device capable of outputting a monaural or a stereo audio signal;

a first headset component for receiving the monoaural or the stereo signal from the electronic device comprising:

a first headset component housing;

a magnetic induction transmitter comprising a transmit loop aerial disposed within the first headset component housing at a first orientation; and

a second headset component capable of wireless communications with the first headset component utilizing magnetic induction communication, wherein the second headset component receives the stereo signal or a component of the stereo signal from the first headset component, the second headset component comprising:

a second headset component housing; and

a magnetic induction receiver comprising a receive loop aerial disposed within the second headset component housing at a second orientation matching the first orientation, wherein the transmit loop aerial and receive loop aerial are axially aligned when the second headset component receives the stereo signal or a component of the stereo signal from the first headset component.

10. The headset system of claim **9**, wherein the electronic device comprises a cellular telephone or digital music player.

11. The headset system of claim **10**, wherein the magnetic induction communication operates at a frequency range between 1 MHz and 20 MHz.

12. The headset system of claim **10**, wherein the magnetic induction communication operate at a frequency of 13.56 MHz.

13. A method for using a headset system comprising:

generating a power-on activation or wake-up signal in a second headset component by touching the second headset component with a first headset component or bringing the second headset component within a range of approximately 3 inches or less from the first headset component;

powering up the second headset component using a second headset component controller responsive to the power-on activation or wake-up signal;

receiving a stereo audio signal at the first headset component;

decoding the stereo audio signal into a first audio channel and a second audio channel, wherein the first audio channel is output by a first speaker at the first headset component; and

transmitting the second audio channel to the second headset component over a wireless link, wherein the second audio channel is output by a second speaker at the second headset component.

14. The method of claim **13**, wherein the wireless link comprises a magnetic induction link between a magnetic induction transmitter and a magnetic induction receiver.

15. The method of claim **13**, wherein the power-on activation or wake-up signal is generated responsive to a voltage induced in a receive aerial in the second headset component.

16. The method of claim **13**, further comprising powering down the second headset component if a magnetic induction carrier falls below a threshold level for a pre-determined period of time.

17. A headset system comprising

a first headset component comprising:

a first headset component housing;

a magnetic induction transmitter comprising a transmit loop aerial disposed within the first headset component housing; and

a second headset component comprising:

a second headset component housing; and

a magnetic induction receiver comprising a receive loop aerial disposed within the second headset component housing, the magnetic induction receiver adapted to receive a signal from the magnetic induction transmitter and the receive loop aerial being so arranged as to align with the transmit loop aerial to receive the signal wherein a first audio channel is output at the first headset component and a second audio channel received from the first headset component is output at the second headset component.

18. The headset system of claim **17**, wherein the magnetic induction transmitter and the magnetic induction receiver operate at a frequency range between 1 MHz and 20 MHz.

19. The headset system of claim **17**, wherein the magnetic induction transmitter and the magnetic induction receiver utilize air-cored coils.

20. The headset system of claim **17**, wherein the second headset component is activated when brought within close proximity to the first headset component.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,627,289 B2
APPLICATION NO. : 11/317984
DATED : December 1, 2009
INVENTOR(S) : David Huddart

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 860 days.

Signed and Sealed this

Second Day of November, 2010

David J. Kappos

Director of the United States Patent and Trademark Office

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF TEXAS
WACO DIVISION

KOSS CORPORATION, Plaintiff, v. APPLE, INC., Defendant.	Case No. 6:20-cv-00665

PLAINTIFF KOSS CORPORATION'S
<u>PRELIMINARY INFRINGEMENT CONTENTIONS</u>

Pursuant to this Court's sample order governing patent cases,[1] Plaintiff Koss Corporation ("Koss") hereby provides its initial infringement contentions and accompanying claim charts ("Infringement Contentions") to Defendant Apple, Inc. ("Apple" or "Defendant").

I. INTRODUCTION

These Infringement Contentions are based in whole or in part on Koss' current knowledge, its current understanding of the proper construction of the asserted claims of U.S. Patent Nos. 10,206,025 ("the '025 Patent"); 10,298,451 ("the '451 Patent"); 10,469,934 ("the '934 Patent"); 10,491,982 ("the '982 Patent"); and 10,506,325 ("the '325 Patent") (collectively, the "Koss Patents-in-Suit"), and its investigation to date. As fact discovery has not yet begun, and will not

[1] A schedule has yet to be entered in this case, however Koss provides these Initial Infringement Contentions consistent with the Default Schedule for this Court, which requires preliminary infringement contentions seven days before the case management conference.

until after the *Markman* process under this Court's default schedule, and as Defendant's core technical documents are not scheduled to be produced until seven weeks after the CMC (which is deemed to have been held on November 13, 2020), these contentions are preliminary and Koss reserves its right to supplement upon the discovery of additional information.

Further, given that the parties have not yet identified proposed terms for construction from the Koss Patents-in-Suit or provided proposed constructions for terms in the Koss Patents-in-Suit, and that the Court has not yet made any claim construction ruling in this action, Koss' Infringement Contentions herein may be made in a variety of alternatives, and not all interpretations are intended to be consistent with each other and/or Koss' other contentions in this action, and should not be otherwise construed. Koss' Infringement Contentions do not constitute admissions or adoptions of any particular claim scope or construction. Koss' Infringement Contentions may apply a variety of constructions in order to provide as full a disclosure as possible in advance of claim construction. Koss objects to any attempt to deduce claim construction positions from these Infringement Contentions.

II. OVERVIEW OF THE INFRINGEMENT CONTENTIONS

Koss contends certain Apple-branded and Apple-sold products and/or systems (collectively, "Accused Products") infringe, directly and/or indirectly, either literally or under the doctrine of equivalents, the following claims of the '025 Patent, the '451 Patent, the '934 Patent, the '982 Patent and the '325 Patent:

- Claims 1–56 of the '025 Patent;
  - Apple- and Beats- branded headphones, including Airpods, Airpods Pro, Powerbeats Pro, Powerbeats, Solo Pro, Solo3, Studio3, and any other product that functions in substantially the same manner as reflected in the attached charts, A-1–A-7.
- Claims 1–7, 9–14, and 16–21 of the '451 Patent;

- Apple HomePod, and any other product that functions in substantially the same manner as reflected in the attached chart, B-1.

- Claims 1–62 of the '934 Patent; and
  - Apple- and Beats- branded headphones, including Airpods, Airpods Pro, Powerbeats Pro, Powerbeats, Solo Pro, Solo3, Studio3, and any other product that functions in substantially the same manner as reflected in the attached charts, C-1 - C-7.

- Claims 1–20 of the '982 Patent.
  - Apple- and Beats- branded headphones, including Airpods, Airpods Pro, and any other product that functions in substantially the same manner as reflected in the attached charts, D-1–D-2.

- Claims 1–18 of the '325 Patent;
  - Apple- and Beats- branded headphones, including Powerbeats Pro, and any other product that functions in substantially the same manner as reflected in the attached chart, E-1.

The claim charts attached hereto as Exhibits A-1–E-1 respectively illustrate how the Accused Products satisfy the various elements of the asserted claims. Koss reserves the right to prove infringement by relying on documents and/or portions of documents other than those cited in Exhibits A-1–E-1, which are intended to be merely exemplary. Koss further reserves the right to supplement and/or amend these Infringement Contentions as appropriate and as permitted under this Court's model schedule, including in response to any non-infringement or claim construction theory asserted by Defendant, in response to any claim construction order issued by the Court, following or in the course of fact or expert discovery, and/or upon the discovery of additional relevant evidence or information.

Koss further reserves the right to prove infringement of any claim limitation under the doctrine of equivalents in the event that claim limitation is deemed not to be satisfied literally, whether due to claim construction or any other reason. Koss additionally reserves the right to supplement and/or amend its Infringement Contentions relating to indirect infringement.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss	
U.S. Patent No.:	10,506,325	Attorney Docket No.: 50095-0022IP1
Issue Date:	December 10, 2019	
Appl. Serial No.:	16/528,703	
Filing Date:	August 1, 2019	
Title:	SYSTEM WITH WIRELESS EARPHONES	

SUPPLEMENTAL DECLARATION OF DR. JEREMY COOPERSTOCK

TABLE OF CONTENTS

Contents

1. I, Dr. Jeremy Cooperstock, declare as follows:

I. INTRODUCTION

2. I have been retained by Fish & Richardson, P.C., on behalf of Petitioner, Apple Inc. ("Apple"), as an independent expert consultant in this *inter partes* review ("IPR") proceeding before the United States Patent and Trademark Office ("PTO").

3. I have been asked by Apple's counsel ("Counsel") to consider whether certain references teach or suggest the features recited in Claims 1-4, 9, 10, and 14-18 of U.S. Patent No. 10,506,325 ("the '325 patent") (APPLE-1001). My opinions and the bases for my opinions are set forth below. My opinions are based on my education and experience.

4. I previously submitted a Declaration in this proceeding that I signed on December 14, 2020, and I understand that the Declaration was marked as APPLE-1003. That Declaration contained my opinions and the bases for them. Since submitting my Declaration (APPLE-1003) I have considered the Board's institution decision (Paper 14), Patent Owner's Response (Paper 20) ("Resp."), the Declarations of Mr. Joseph C. McAlexander III (KOSS-2035) and Mr. Nicholas Blair (KOSS-2036) in support of the Response filed by Patent Owner, Koss Corporation ("Koss"). My opinions from my previous Declaration have not changed.

II. BACKGROUND AND QUALIFICATIONS

5. My background and qualifications are set forth in my previous Declaration. I incorporate that section of my previous declaration here by reference.

III. INFORMATION CONSIDERED

6. In preparing this declaration, I have considered the materials discussed in this declaration, including, for example, the '325 patent, the references cited by the '325 patent, the prosecution history of the '325 patent, background articles and materials referenced in this declaration, and the prior art references identified in this declaration. In addition, my opinions are further based on my education, training, experience, and knowledge in the relevant field.

Document No.	**Description**
APPLE-1001	U.S. Patent No. 10,506,325 to Koss et al. ("the '325 patent")
APPLE-1002	Excerpts from the Prosecution History of the '325 patent ("the Prosecution History")
APPLE-1003	Declaration of Jeremy R. Cooperstock
APPLE-1004	U.S. Pat. App. Pub. No. 2008/0076489 ("Rosener")
APPLE-1005	U.S. Pat. No. 7,627,289 ("Huddart")
APPLE-1006	Certified Translation of WO 2006/042749 ("Haupt")
APPLE-1007	U.S. Pat. No. 5,371,454 ("Marek")
APPLE-1008	U.S. Pat. App. Pub. No. 2006/0026304 ("Price")
APPLE-1009	U.S. Pat. No. 7,551,940 ("Paulson")
APPLE-1010	U.S. Pat. No. 7,027,311 ("Vanderelli")

APPLE-1024	Joseph C. McAlexander III Deposition Transcript, Dec. 14, 2021
APPLE-1025	U.S. Pat. App. Pub. No. 2008/0166001 ("Hankey")
APPLE-1026	U.S. Pat. App. Pub. No. 2008/01191398 ("Kim")
APPLE-1027	Jabra Talk 5 Datasheet, *available at* https://www.jabra.com/bluetooth-headsets/jabra-talk-5##100-92046900-02
KOSS-2035	Declaration of Joseph C. McAlexander, III
KOSS-2036	Declaration of Nicholas S. Blair
Paper 14	Institution Decision
Paper 20	Patent Owner Response ("Resp.")

IV. RELEVANT LEGAL STANDARDS

7. I set forth the relevant legal standards in my previous declaration, and I incorporate those legal standards here by reference.

V. SUMMARY OF MY OPINIONS

8. I have been asked to consider whether the claims of the '325 patent are anticipated or obvious over certain prior art references. As explained in my previous declaration and in further detail in this declaration, it is my opinion that:

- Claims 1, 2, and 16-18 are obvious over Rosener and Huddart
- Claims 3 and 4 are obvious over Rosener, Huddart, and Haupt
- Claims 9, 10, and 14 are obvious over Rosener, Huddart, and Price
- Claim 15 is obvious over Rosener, Huddart, and Paulson
- Claims 16 and 17 are obvious over Rosener, Huddart, and Vanderelli

VI. THE ’325 PATENT

A. Priority Date

9. For purposes of my analysis, I apply April 7, 2008 (“Critical Date”) as the earliest purported priority date of the ’325 patent. All of the prior art relied on in this declaration were published and/or filed before the Critical Date.

B. Level of Ordinary Skill in the Art

10. I provided my opinion about a person of ordinary skill in the art (POSITA) in my previous declaration, and I incorporate that opinion here by reference.

VII. ANALYSIS

11. I analyzed how the combinations of Rosener, Huddart, and/or Price makes various claims of the ’325 patent obvious in my previous declaration. I incorporate that analysis here by reference. In this declaration, I further address Koss’s statements relating to the prior art discussed in my previous declaration.

A. Claim 1 is Made Obvious By The Combination of Rosener and Huddart

1. Overview

12. Koss argues that “a POSITA would not add Rosener’s earloop to Rosener’s wireless earbuds depicted in FIG. 5.” Resp., 14-15. Koss cites to the Blair Declaration to argue that “adding an earloop to an earphone with an earbud and a downwardly extending member…would counteract the securing forces of the

earbud-downwardly extending member earphone and actually work to pry the earbud out of the user's concha." Resp., 16 (citing KOSS-2036, 16). I disagree with the Blair Declaration for several reasons.

2. The Blair Declaration

13. I disagree with the Blair Declaration's overall conclusion that incorporating earloops into Rosener's earphones 502, 504 would result in the earbuds falling out of the user's concha. The Blair Declaration assumes a specific configuration of the earphones that includes a downwardly-extending member. The analysis in the Blair Declaration is also incomplete and makes several other assumptions that are discussed below.

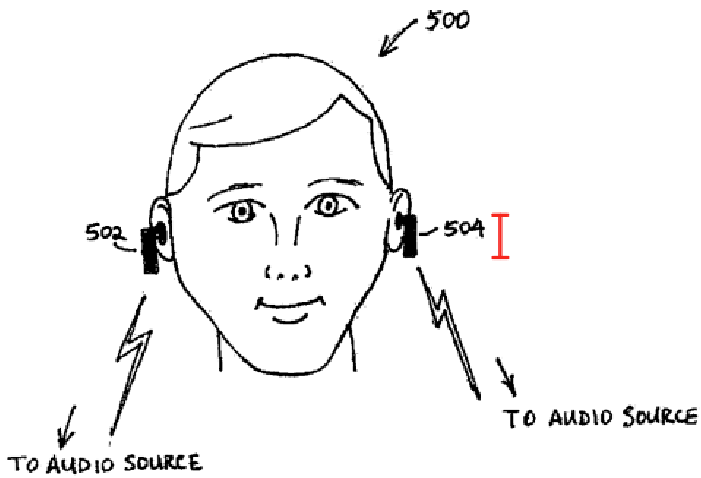
a) <u>The Blair Declaration Assumes A Configuration Of Extending Members</u>

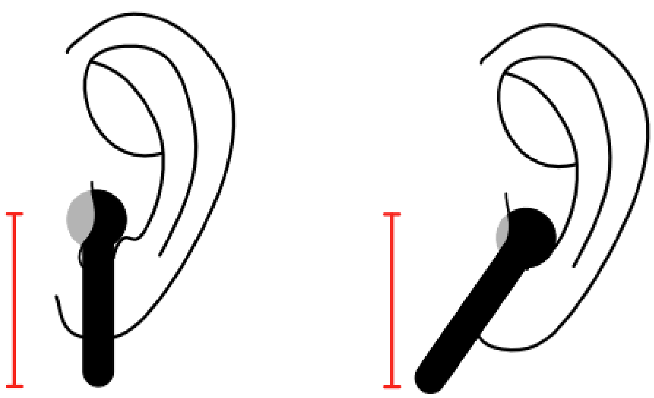
14. The Blair Declaration states that the "securing mechanism" of earphones 502, 504 includes "a downwardly-extending member that extends for the earbud portion of the earphone." KOSS-2036, ¶11. The Blair Declaration also cites to a "free-body diagram representing the force(s) acting on the earphone 502, 504 by the downwardly-projecting member." *Id.*, ¶15. This is shown in Diagram 3 below:

Diagram 3

15. Diagram 3 assumes that the extending member of earphones 502, 504 takes on a specific configuration where the downward direction extends in the downward direction. However, the Blair Declaration does not explain or address other configurations where the extending member is not strictly pointing downwards. KOSS-2036, ¶¶11-13.

16. Rosener's Figure 5 also does not limit earphones 502, 504 to the specific configuration shown in Diagram 3. Figure 5 shows a front view of the extending members as generic structures, and from this view, the direction of extension of the extending members is not precisely clear. The annotated figure below shows two possible extrapolations of the vertical lengths of the generic structures depicted in Figure 5. *Id.* In the annotated figure, vertical lengths are depicted by a red line, which is similarly depicted in the two extrapolations.





17. Though the two extrapolations have devices with extending members that are positioned differently relative to the ear, the vertical lengths of each of their extending members would appear the same in a frontal view (i.e., the view shown in Rosener's Figure 5). Because of this ambiguity, the depiction of earphones 502, 504 in Rosener's Figure 5 does not clearly indicate how the extending members are positioned relative to the user's ear.

b) <u>The Blair Declaration's Conclusion of Incompatibility Is Questionable</u>

18. As explained above, the Blair Declaration concludes that earloops

"would not work with the earbuds depicted in Rosener's Figure 5" (KOSS-2036, ¶13) because it would "defeat[] the purpose of the securing mechanisms for such an earphone" (*id.*, ¶16). However, this conclusion requires several leaps that I explain in detail below.

19. The first leap involves the direction and magnitude of the resultant force that the Blair Declaration states "would essentially pry the earbud out of the concha…" *Id.*, ¶16. The free-body diagrams (below) used to analyze this resultant force do not identify and account for various other constituent forces that would have also acted on earphones when placed in a user's ear.

Diagram 3

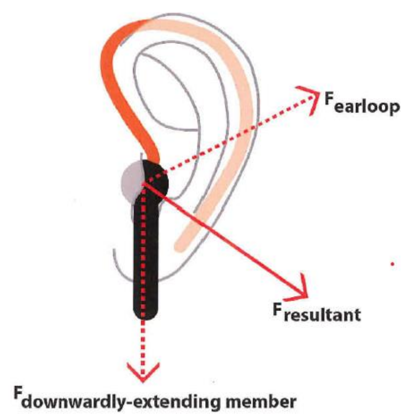


Diagram 4

20. The forces missing in Diagrams 3 and 4 result from various earphone surfaces contacting corresponding surfaces of the user's ear when the user wears the earphones. One example of such contact is the surface of the earbud portion contacting the concha surface. Another example is the surface of the earloops contacting the top portion of the outer ear. The forces acting on the earphones

include frictional forces and normal forces. The rigidity and positioning of the earloop (e.g., around the outer portion of the user's ear) would have also helped with retention to counteract the downward force acting on the earphones. Other forces acting on the earphones are those that would exist due to the rigidity of the earloop.

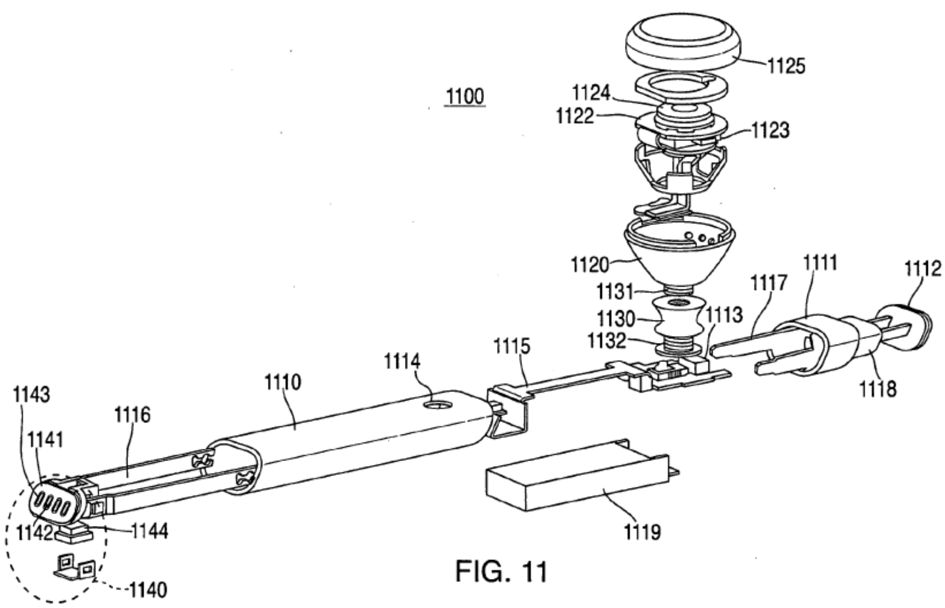
21. The accuracy of the force diagrams in the Blair Declaration (Diagrams 2-4) is questionable because they miss several forces that would be acting on the earphones when they are worn by the user. The accuracy of the $F_{resultant}$ shown in Diagram 4 is also questionable since the Blair Declaration does not explain how two constituent forces ($F_{earloop}$, $F_{downwardly\text{-}extending\ member}$) are combined. A resultant force is the final force that acts on an object after combining via vector addition all the individual forces acting on the body. Vector addition involves considering both the angles and magnitudes of constituent forces in calculating the resultant force. While Diagram 4 seems to consider the angles of the two constituent forces, the Blair Declaration does not include any mathematical calculations. Specifically, the Blair Declaration also does not discuss values of the angles and force magnitudes necessary to carry out vector addition. Without these calculations, including the respective angles and magnitudes of constituent forces, it is not clear how the Blair Declaration arrives at the specific direction of resultant force shown in Diagram 4.

22. I disagree with Koss's argument that "the resultant force would essentially pry the earbud out of the concha" since the Blair Declaration does not include any magnitude information of the resultant force shown in Diagram 4. Unless the magnitude of the resultant force is sufficiently high to counteract other forces (e.g., frictional forces and normal forces), then it would not have been understood to pry the earbud out. A helpful analogy is to think about a stationary glass cup sitting at rest on a table. If the glass has a central center-of-mass, in order for an external force to be applied to the glass cup to cause it to tip over, the force needs to have a magnitude that is greater than a frictional force that resists it. Only if the external force applied to the glass cup is greater than the frictional force (and other forces acting on the cup) will the cup eventually tip over.

23. The Blair Declaration makes another leap in assuming certain weight distributions of the earphones. In the configuration shown in Diagrams 3 and 4, the Blair Declaration does not state where the center-of-mass is in the earphones and seems to assume that the center-of-mass is skewed towards the bottom portion of extending member, which it believes would have resulted in the downward force ($F_{\text{downwardly-extending member}}$) causing the earphones to fall out of the user's ear(s).

24. The Blair Declaration does not consider other implementations that could have reduced the $F_{\text{downwardly-extending member}}$ shown in Diagrams 3 and 4. One option to accomplish this is to adjust the center-of-mass of the earphones to be near

the earbud portion of the device (i.e., the top portion). An example of this configuration is disclosed in U.S. Pat. App. Pub. No. 2008/0166001 to Hankey ("Hankey"; APPLE-1025). In Hankey's Figure 11, for example, electronic components, including earbud circuit board 1122, processor 1123, receiver 1124, are housed in an earbud housing 1120. APPLE-1025, ¶[0147].



APPLE-1025, FIG. 11

In the implementation shown in Hankey's Figure 11, the downwardly-extending member would not necessarily produce a meaningfully significant downward force that creates retention issues. This is because if the center-of-mass is understood to be in the earbud portion, then the downward force imposed by weight of the earbud portion would be counteracted with an upward normal force exerted by the concha of the user's ear. With this type of weight distribution, the downward force

imposed by the extending member would not necessarily pry the earphones out of the user's ear.

25. Additionally, even if we were to accept Mr. Blair's characterization of the downward force creating some tendency to remove the earbud from the ear, it is also possible that the rigidity of the earloop would counteract the downward force provided by the extending member and effectively resist it, eliminating or reducing any retention issues.

3. Earphone Configurations With Earloops and Extending Members

26. I also disagree with the Blair Declaration's conclusion that incorporating earloops into Rosener's earphones would result in the earbuds falling out of the user's ear(s) since this configuration exists in both the prior art and in commercially available products. This suggests that, despite Koss's arguments, a POSITA would have been capable of implementing earphones with both an earloop and an extending member.

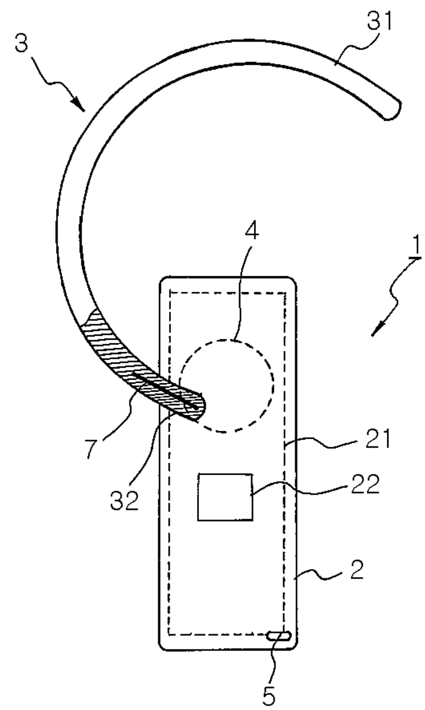
a) A POSITA Would Have Understood How To Implement Earphones With An Earloop And A Downwardly-Extending Member

27. A POSITA would not have agreed with the configuration shown in the Blair Declaration where the extending member is directed entirely in the downward direction. This is because the POSITA would have recognized that some users would have preferred to orient the earphones such that extending

members are oriented at an angle relative to the ear. Users would have preferred this orientation since it would have allowed a microphone positioned closer to a user's mouth, thereby increasing audio data quality.

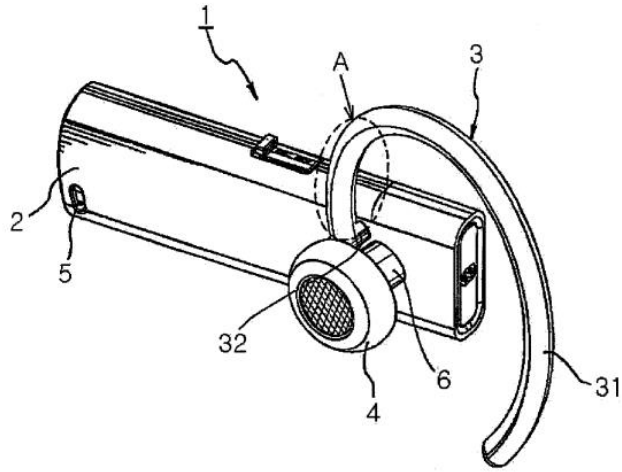
28. A POSITA also would not have agreed with the Blair Declaration's conclusion that the downward force applied by the extending member would pry the earphones out of the user's ear. A POSITA would have understood that configurations in which the center-of-mass is in the earbud (e.g., the earphone implementation in Hankey), the downward force imposed by weight of the earbud portion would be counteracted with an upward normal force exerted by the concha of the user's ear. A POSITA would have also understood that rigidity of the earloop allows it to counteract or resist the downward force exerted by the downward member by contacting the surfaces of the outer ear.

29. Earphones with an earloop and an extending member (e.g., a downwardly-extending member) were also well-known by the Critical Date. A POSITA would have therefore had the knowledge to implement such a configuration by the earliest priority date of the '325 patent. For example, U.S. Pat. App. Pub. No. 2008/0119138 to Kim ("Kim"; APPLE-1026) was filed on November 9, 2007 and discloses earphones with an earloop and a downwardly-extending member, as shown in Figure 2:



APPLE-1026, Figure 2

30. Kim describes that a Bluetooth headset includes a body 2 and an earhook 3 protruding from the body with a certain radius of curvature. APPLE-1026, ¶[0023]. Kim also describes a microphone 5 is disposed on one end of the body 2 and the other end of body 2 is provided with an earphone 4 protruding from the neck portion 6. *Id.*, ¶[0026]. Figure 1 shows that the shape of earphone 4 has an earbud form factor.



Kim further describes that ear hook 3 includes a hook portion 31 having a specific radius of curvature to be worn on the user's ear and a fixing portion 32 fixed to the body 2. *Id.*, ¶[0026]. Based on Kim's disclosure, a POSITA would have understood that earphones with an earbud form factor and having both an earloop and an extending member were conventional as of the Critical Date. Kim's disclosure also suggests that a POSITA would not be discouraged from implementing a similar configuration in earphones.

31. Additionally, the existence of commercially available earphone products with earloops and extending members further refutes that the configuration is inoperable. For example, the Jabra Talk 5 (shown below) include earphones with an earbud form factor, include an earloop as a securing mechanism, and also include an extending member. APPLE-1027. This product further confirms that a POSITA would have understood how to implement earphones with an earloop and an extending member.

APPLE-1027

32. The extending member of the Jabra Talk 5 could also be understood to represent Koss's "downwardly-extending member" since a POSITA would have understood that the device could be oriented in a user's ear in different ways. Some users could have oriented the device so that its extending portion is pointed downwards. Given differences in the anatomical structures of ears, some users would have also worn the device so that the extending member is primarily faced downwards.

b) The '325 Patent Does Not Describe Earloop Compatibility As Being Crucial To Its Supposed Invention

33. The '325 patent specification also confirms that a POSITA would have understood how to implement earphones with earloops and downwardly-extending members since it does not describe the compatibility issues identified in the Blair Declaration. The '325 patent describes a bar 17 in descriptions of Figures

1D and 1E that "allows the earphones 10 to clip to, or hang on, the user's ear…" APPLE-1001, 4:4-7. These descriptions do not focus on forces provided by the bar 17 to improve retention. APPLE-1001, 4:4-7.

4. Rosener's Disclosure

34. Koss argues that Rosener is ambiguous in describing earphones with an earbud form factor and also having both an earloop and a downwardly-extending member. Resp., 19-20. I disagree because Rosener's descriptions in paragraph [0030] clearly describe the opposite. This paragraph initially states that "[e]ach of the first and second earphones 502, 504 may be ***in the form of an earbud*** designed to fit into the concha of the pinna of the user's ear" and then describes that "[e]ach of the first and second earphones 502, 504 may ***further include a clip, earloop***, or other suitable securing mechanism to help maintain the earloop 502 or 504 on the ear of the user." APPLE-1004, ¶[0030] (emphasis added). These descriptions confirm that Rosener describes at least one embodiment in which earphones 502, 504 are "in the form of an earbud" and "further include…[an] earloop." *Id*.

B. Claim 18 is Made Obvious By The Combination of Rosener and Huddart

1. Overview

35. Koss argues that Rosener's signal conditioning circuit 916 is not a digital signal processor but instead a digital-to-analog (DAC) converter. Resp., 20-

26. Koss also argues that a POSITA would not have been motivated to use Huddart's "low-power" battery in Rosener's earphones because the battery would not have been able to sufficiently power a digital signal processor. *Id.*, 27-32.

36. I disagree with both of Koss's arguments for claim 18. The first argument incorrectly characterizes signal conditioning circuit 916 and ignores teachings in Rosener that would have led a POSITA to understand that signal conditioning circuit 916 is a digital signal processor. The second argument makes certain assumptions of Huddart's battery by confusing battery capacity and power capacity.

2. Rosener's Signal Conditioning Circuit 916

37. Koss characterizes Rosener's signal conditioning circuit 916 as "a digital-to-analog converter (DAC) because a POSITA would understand that a DAC in a wireless headphone like Rosener's 'drives' the speaker." Resp., 23; KOSS-2035, 50. I disagree with this characterization for two reasons. First, it conflicts with Rosener's disclosure addressing several functions performed by signal conditioning circuit 916. Second, it also incorrectly asserts that "digital-to-analog conversion" is not a "signal processing function."

a) Rosener's Descriptions of "Signal Processing Function"

38. Koss states that "a POSITA would understand that a DAC in a wireless headphone like Rosener's 'drives the speaker" and that it "converts the

digital signal from the baseband processor 914 to an analog signal because the data sink/speaker 918 is driven by an analog signal." Resp., 23. But Rosener also provides a non-exhaustive list of "signal processing functions" performed by signal conditioning circuit 916, such as "digital-to-analog conversion, filtering, amplification." APPLE-1004, ¶[0049]. This disclosure makes clear that signal conditioning circuit 916 performs more than just "digital-to-analog conversion" and interpreting signal conditioning circuit 916 as only DAC, ignores Rosener's disclosure of "filtering," "amplification" and "other signal processing functions."

39. Rosener also describes signal conditioning circuits 701, 826, and 922. These elements similarly provide filtering, amplification and/or other signal processing functions. Rosener, ¶¶[0044], [0047], [0050]. If signal conditioning circuit 916 were interpreted to represent a DAC, as Koss argues, then similar interpretations would need to be applied to signal conditioning circuits 701, 826, and 922. This confirms that Koss's interpretation is too narrow.

40. Rosener also describes that "digital-to-analog conversion" is an example of a "signal processing function." APPLE-1004, [0044], [0047], [0050]. Koss focuses more specifically on "digital-to-analog conversion" to drive an audio device as not representing a "digital signal processor." But Rosener also teaches discrete analog-to-digital (A/D) and digital-to-analog (D/A) converters (e.g., A/D converter 910, D/A converter 912) and if the signal conditioning circuit 916 was

interpreted to only represent a DAC, which conflicts with Rosener's disclosure.

b) Koss's Interpretation of "Digital Signal Processor"

41. Koss also cites to the '325 patent in interpreting the meaning of "digital signal processor" as being "embodied as a single chip (i.e., integrated circuit)." Resp., 25. However, the claim language does not state that the "digital signal processor" is embodied as a single chip. The '325 patent also makes clear that descriptions that Koss refers to are specific implementations. APPLE-1001, 6:30-31 ("FIG. 3 is a block diagram of the earphone 10 according to ***various embodiments*** of the present invention) (emphasis added); 7:30-32 ("The baseband processor 12 may be in communication with a processor unit 114, ***which may*** comprise a microprocessor 116 and a signal processor (DSP) 118") (emphasis added).

3. Huddart's Battery

42. Koss also argues that the battery in Huddart's earbud 6 is a "low-power battery" that would have been unable to power any digital signal processor when incorporated into Rosener's earphones. Resp., 27-32. I disagree with this because Huddart does not disclose the power capability of earbud battery 6.

a) Koss Assumes That Huddart Discloses a "Low-Power" Battery

43. Koss points to two disclosures in Huddart to support its view that Huddart's battery is "incompatible for use to power the claimed DSP and baseband

processor due to its small capacity…" Resp., 30. The first disclosure is wireless communication between headset 4 and earbud 6 being based on "[m]agnetic induction [that] provides short range wireless communication at ***low power*** and cost while providing good signal quality." APPLE-1005, 3:21-23 (emphasis added). The second is the earbud 6 battery having "a relatively ***smaller capacity*** battery due to its limited size." APPLE-1005, 8:31-34 (emphasis added).

44. The two disclosures in Huddart cited by Koss do not address power capability of the earbud 6 battery. Power capability is the maximum output power of an energy storage system (e.g., battery) that does not exceed the over- and under-voltage limit conditions in the current state of charge (SOC) of the energy storage. In the case of batteries, the power capability can be a very important parameter in terms of electrical stability as well as driving performance. Battery capacity itself does not indicate power capability since a battery can be designed in different ways to achieve various functions.

b) Koss Also Assumes That Digital Signal Processors Require Specific Batteries

45. Koss also argues that "a larger-capacity battery was needed to power the additional components of an earbud, such as a DSP and baseband processor per claim 18…" Resp., 28. Koss also states that other batteries "would be too heavy to be used in a wireless earphone." *Id.*, 30-31. I disagree with these statements since Koss does not explain how or why DSPs and baseband processors have

sufficiently high power consumption to require a larger-capacity battery. Koss also does not address the weights of larger-capacity batteries and their incompatibilities in wireless earphones.

c) The ’325 Patent Does Not Describe Battery Power Capability As Being Crucial To Its Supposed Invention

46. The ’325 patent discloses a “power source 102” that includes “a rechargeable or non-rechargeable battery (or batteries).” APPLE-1001, 6:56-57. The ’325 patent does not address power output in relation to DSP functionality. The disclosure of DSP functionality is limited to three sentences focused on sound quality enhancements, such as noise cancellation and sound equalization. APPLE-1001, 7:30-37, 13:50-54. The ’325 patent also does not teach that its DSP requires heightened battery power requirements. The absence of these descriptions suggests that the ’325 patent considered a rechargeable battery with sufficient power capability to operate a set of wireless headphones with digital signal processors conventional by the Critical Date. A POSITA also would have known how to use a rechargeable battery with sufficient power capability to operate a set of wireless headphones (as is disclosed in Rosener) to address any such purported heightened power requirements of DSPs.

C. Claims 9 and 10 Are Made Obvious By The Combination of Rosener, Huddart, and Price

1. Overview

47. Koss argues that a POSITA would not have used Huddart’s earbud

battery 6 with wireless earphones that have additional power consumption associated with receiving firmware upgrades. Resp., 33-35. I disagree with this statement because there are different types of firmware upgrades that involve different amounts of power consumption. Additionally, even if firmware upgrades were understood to involve significant power consumption, a POSITA would have known how to use a rechargeable battery with sufficient power capability to operate a set of wireless headphones (as is disclosed in Rosener) to address any such purported heightened power requirements of the firmware upgrades.

2. Firmware Update Functionality

48. Koss argues that Huddart's battery would not have been suitable for a wireless earphone that additionally receives firmware upgrades. Resp., 33-35. This assumes that implementing firmware upgrades on a device involves significant power consumption. Koss does not explain why implementing a firmware upgrade involves significant power consumption. *Id.*, 33. Koss also does not analyze the time required for a device to implement a firmware upgrade, which impacts power consumption.

49. Koss focuses on disclosure in the '325 Patent of a single integrated circuit, such as a system-on-chip (SoC), being used to reduce power consumption by miniaturizing system components of earphone 10. *Id.*, 35. Koss states that "[t]he reduced power requirements allow for the use of rechargeable batteries and

firmware updates for wireless earphones." *Id.* Claims 9 and 10 do not describe any feature corresponding to an integrated circuit or a SoC.

3. Configuring Firmware Upgrades

50. Even if certain types of firmware upgrades do involve high power consumption, a POSITA would have known how to implement the Rosener-Huddart-Price combination to avoid this issue. A firmware upgrade can have different completion times depending on the nature of the update provided by the firmware upgrade. For example, an incremental firmware upgrade may not actually involve high power consumption because of how quickly a device performs the firmware upgrade. Examples of incremental firmware upgrades include minor performance updates, driver optimizations, or updates to existing hardware functionalities and capabilities. A POSITA would have recognized that incremental firmware upgrades do not necessarily impose significant power burden. Even if a device has a low-power or low-capacity battery, a POSITA would have understood that the device can be configured to permit an incremental firmware upgrade without requiring any external power.

51. Additionally, a POSITA would have understood how to implement the Rosener-Huddart-Price combination to avoid any power consumption issues associated with firmware upgrade functionality with a reasonable expectation of success. The POSITA would have known several configuration options for this

implementation. One technique is by conditioning firmware upgrades based on the battery charge level (e.g., upgrading firmware upgrades only if the charge level surpasses a threshold). Another involves requiring that the battery be charged for a firmware upgrade (e.g., a device could send a warning to the user indicating that the battery would need charging before upgrading the earphone's firmware).

52. Koss describes another configuration option that could avoid power consumption issues since it discusses that "devices will not download firmware updates unless they are plugged in for power; or at least they will provide a warning that the device should be plugged in for the firmware download." Resp., 33. A POSITA could have also implemented this configuration in the Rosener-Huddart-Price combination with a reasonable expectation of success. Huddart teaches a charger/carrier that includes a "charger circuit for charging both the headset battery and wireless earbud battery when inserted into the pocket charger/carrier[]" and "provides a convenient mechanism by which the earbud 6…may be recharged in the absence of a primary charger." APPLE-1005, 8:28-34. Huddart also teaches a "primary charger to which the pocket charger may be removably attached[]" and that the "primary charger may be a cable or a docking facility connecting the pocket charger/carrier to a wall outlet…" APPLE-1005, 8:51-57).

53. If power consumption was understood to be an issue for implementing

a firmware upgrade, then a POSITA would have implemented the Rosener-Huddart-Price combination so that the earphones install firmware upgrades when they are placed in Huddart's charger/carrier and connected to a wall outlet through the primary charger. This implementation would have been within the POSITA's capability since Huddart teaches a mechanism through which its earphones can receive power from a "wall outlet" and Price teaches earphones with firmware upgrade capability. APPLE-1005, 8:51-57.

VIII. ADDITIONAL REMARKS

54. I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

55. I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code.

Dated: December 23, 2021

By: ______________________
Jeremy Cooperstock

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,)
)
Petitioner,) Case IPR2021-00305
) Patent 10,506,325
vs.)
) Case IPR2021-00381
KOSS CORPORATION,) Patent 10,491,982
)
Patent Owner.)

The Zoom video deposition of JOSEPH McALEXANDER, III, taken before Richard Derrick Ehrlich, Registered Merit Reporter, Certified Realtime Reporter, taken pursuant to the United States Patent and Trademark Office Rules, commencing at 9:00 a.m., on the 14th day of December, 2021.

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I N D E X

E X H I B I T S

VIDEOGRAPHER: Good morning. We are going on the record. The time is 11:32 a.m. on December 14th, 2021.

This is Media Unit 1 of the video-recorded deposition of Joseph McAlexander, III, taken by counsel for the petitioner in the matter of Apple Inc. vs. Koss Corporation filed in the United States Patent and Trademark Office, Case No. IPR2021-00381 and IPR2021-00305.

This deposition is being held remote Zoom videoconference. My name is Justin Henricksen, and I'm from the firm Veritext, and I'm the videographer. The court reporter is Richard Ehrlich from the firm Veritext.

I'm not related to any party in this action, nor am I financially interested in outcome.

Counsel and all present in the room, everyone attending remotely will now state their appearances and affiliations for the record. If there are any objections to the proceedings, please state them at the time of your appearance beginning with the taking attorney first.

MR. PIEJA: Good morning. Michael Pieja of

Goldman Ismail on behalf of Apple, the petitioner in this action.

Also present on the line appearing on behalf of Apple are Jennie Hartjes of Goldman Ismail and Parvine Ghane and Roberto Devoto and Ryan Chowdhury of Fish & Richardson.

MR. KNEDEISEN: Mark Knedeisen from K & L Gates for patent owner Koss Corporation. I believe also on the line is Michelle Weaver from K & L Gates.

VIDEOGRAPHER: Thank you.

Will the court reporter please swear in the witness?

JOSEPH McALEXANDER, DEPONENT, SWORN

EXAMINATION

BY MR. PIEJA:

Q Good morning, Mr. McAlexander.

A I guess it still is. Good morning.

Q Indeed. I do apologize for the delay this morning, and I thank you for your patience and appreciate your taking the time to stick with us while we got those administrative issues sorted out.

Can you state your full name for the

record?
A Full name is Joseph Colby McAlexander, III.
Q Where are you sitting for your deposition today, sir?
A I'm sitting in my home office in Anna, Texas.
Q Is there anyone else present with you in the room where you're sitting for your deposition?
A No, sir. Nobody.
Q And are you communicating with anybody else via any apps on either your phone or your computer or any other electronic device as you sit there to take -- to sit for this deposition?
A No.
MR. KNEDEISEN: Let me just note, Michael, that I emailed -- sent him two emails with the exhibits.
MR. PIEJA: Absolutely. Thank you for the clarification, Mr. Knedeisen.
BY MR. PIEJA:
Q Mr. McAlexander, do you understand that you're here today to be deposed in -- with regard to declarations you submitted in connection with two IPR proceedings, IPR2021-305 and IPR2021-381?

Q That sentence, like the one we just read, is referring to the same earphones 502, 504 that are referenced in the first sentence of paragraph 30 of Rosener, correct?
A Yeah. And it states that they may include.
Q Right. This sentence doesn't say that only some forms of earphones 502, 504 may include an earloop, does it?
MR. KNEDEISEN: Objection.
THE DEPONENT: If you're asking did the patent agent that wrote this use your words, the answer is no.
BY MR. PIEJA:
Q Okay. Well, there's nothing in paragraph 30 of Rosener that says that only some forms of earphones 502, 504 may include an earloop, correct?
A It does not use those words. When a person skilled in the art reads this, he would have an understanding that in some forms you may use it, in some forms, you may not. And that's why I think the appropriate word is you "may" further include.
Q So the answer to my question is no, right?

out of the user's ear or to fall out of the
user's ear, does it?
A It doesn't make that statement, but simple
mechanics, when you look at cantilevers, you can
understand that that would be the case. That
has to be encountered and incorporated in the
design. Otherwise, you will have a misnomer.
If you're asking me was Rosener very
deficient on how much he provided information
about those limitations, yes, he was very much
light on his explanations.
Q Actually, no, that wasn't what I was asking you.
What I was just asking you was whether or
not paragraph 30 of Rosener states or explains
that adding an earloop to any form of
earphones 502, 504 could cause them to be pried
or fall out of the user's ear.
MR. KNEDEISEN: Objection.
THE DEPONENT: Rosener has not made that
statement.
BY MR. PIEJA:
Q Your declaration doesn't identify anything in
Rosener that states or explains that using an
earloop in any particular form of earphones 502,

A I see that.
Q An earbud is a tiny speaker that sits in the user's ear, correct?
A It is a form in which a tiny speaker fits that goes into the ear, yes.
Q So an earbud includes a tiny speaker and sits within the user's ear, correct?
A Within the outer portion of the ear, yes.
Q A canalphone is like an earbud but fits snugly in the user's ear canal, correct?
A I'm not sure how snugly, but that's the intent, to fit in the canal.
Q Well, in paragraph 42 of your declaration, you state that, quote, A canal bud is like an earbud but fits snugly inside the user's ear canal, correct?
A That's correct. That's the intent.
Q All right. And an over-the-ear circum-aural headphone is a headphone that is worn around the ear and fully encompasses the ear, correct?
A If it's a circum-aural, yes, that's correct.
Q You would agree that Rosener's Figure 5 may show an earbud configuration, correct?
A Bringing Figure 5 back up. Yes, it may.

circum-aural over-the-ear headphone, correct?
A There's not a need to do so for circum-aural.
Q So it's your opinion that a person of skill reading paragraph 30 of Rosener would understand that none of the three specifically disclosed forms of earphones -- an earbud, a canalphone, or a circum-aural headphone -- would include or could include an earloop, correct?
MR. KNEDEISEN: Objection. Form.
THE DEPONENT: I cannot agree with your statement because he says in paragraph 30 of Rosener, at the last line of paragraph 30 on page 16, following on the top of page 17, Each of the first and second earphones 502, 504 may further include a clip, earloop, or other suitable securing mechanism.
So he certainly covered many different ways in which his particular illustration can take a form. So since he says that each of the earphones 502 and 504 may be in the form of an earbud, a canalphone, or an over-the-ear circum-aural or other suitable -- and then he says, Each of those first and second earphone 502, 504 may further include. So they could

include.

BY MR. PIEJA:

Q They could include an earloop, correct?

A That's right. In his embodiment, they could.

Q And a person of skill would understand that, correct?

A A person of skill would understand that these are all combinations that can be considered, but then when one of skill in the art begins to process that and see what works and what does not, he would not necessarily -- in fact, he would not combine something that lacks utility or would not work or would actually counter the quality of the sound that is taking place because the whole thrust of this is the sound quality and the noise -- and the cancellation of anything because of the fit that keeps extra noise out.

So anything that is done in terms of these combinations that's going to go against what the intent is, it certainly goes against the teaching of Rosener.

Q And in your view, that is true of all three of the form factors disclosed in paragraph 30 of

Rosener: The earbud, the canalphone, and the circum-aural headphones, correct?

MR. KNEDEISEN: Objection.

THE DEPONENT: What is true?

BY MR. PIEJA:

Q Your opinion that, succinctly put, a person of skill would believe that including an earloop on the headphones would have some sort of negative or disadvantageous result.

A No, I didn't say that. It is a consideration that one has to make when you look at these. For instance, Figure 4 shows that when you use the overloop as a counterbalance to the projection for the mike, now you've got it balanced, and that works fine.

So there are certain considerations that one would make but others one as a person skilled in the art would not do.

Q Okay. Let's -- you would agree that paragraph 30 of Rosener discloses three specific potential forms for the earphones: Earbud, canalphone, circum-aural, correct?

A It does mention those three.

Q Those are the only three specific potential

forms for the earphones disclosed in
paragraph 30 of Rosener, true?
A Those are the only ones that are specifically
identified.
Q And your testimony sitting here today is that a
POSITA reading paragraph 30 of Rosener would
have concluded that including an earloop in any
of those three disclosed forms would be
inappropriate, correct?
MR. KNEDEISEN: Objection. Form.
THE DEPONENT: I stated just the opposite
because if I agree with your statement, that
would counter what he says on the next sentence,
that each of the first and second earphones --
earphone 502, 504 may further include, the words
"further include." So in addition to these
three, they may also include this.
So I didn't say that it cannot be, but one
has to take into consideration the particular
structure that one is to use, and my opinion,
consistent with what Mr. Blair has put forward,
is that when you do an earloop in combination
with an earbud, that there are going to be
forces that will tend to dislodge it and will

disrupt the quality of the listening.
BY MR. PIEJA:
Q Based on that view, it is your opinion that a person of skill would not have found it obvious based on paragraph 30 of Rosener to include an earloop on the earbud configuration disclosed in that paragraph, correct?
A That's correct.
Q Based on your view -- withdrawn.
Based on that view, it is also your opinion that the person of skill would not have found it obvious based on paragraph 30 of Rosener to include an earloop on the canalphone configuration disclosed in that paragraph, correct?
A I think I said that the resultant is not going to be as severe but there's still going to be a quality degradation by doing so. If -- again, it's with the understanding that you've got the downward projection aspect. That's what is shown.
Q Is it your opinion sitting here today that a person of skill in the art would have found it obvious based on paragraph 30 of Rosener to

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(54) **BLUETOOTH HEADSET WITH BUILT-IN ANTENNA MODULE**

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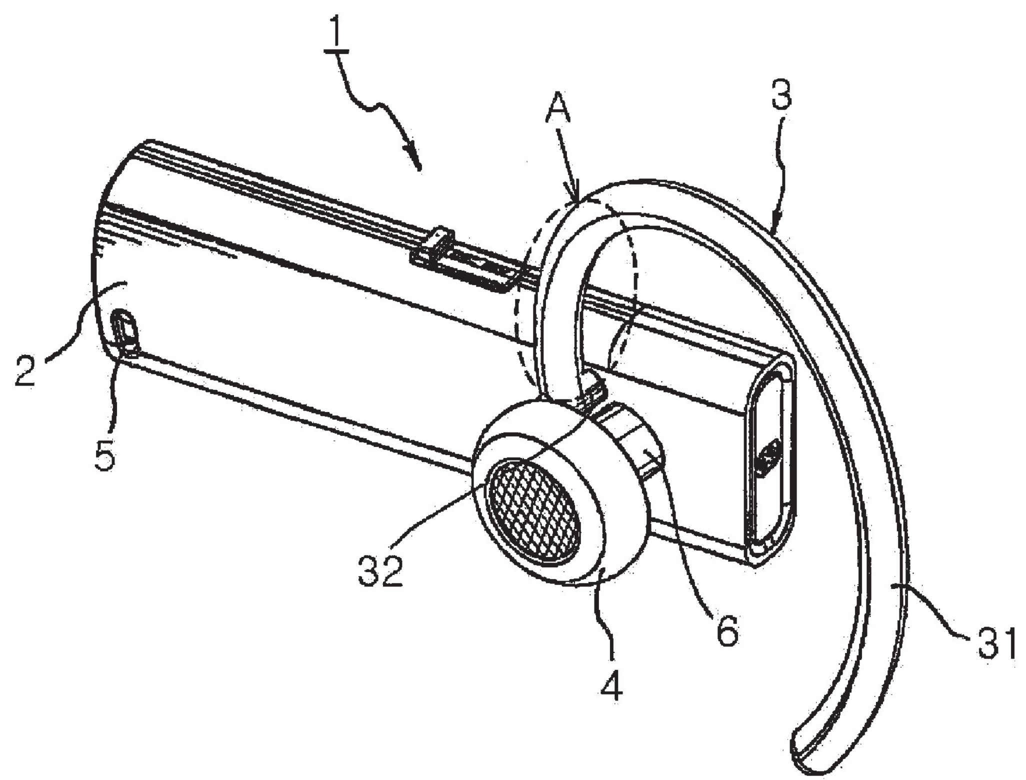
H04M 1/00 (2006.01)

(52) **U.S. Cl.** **455/41.2**; 455/575.2

(57) **ABSTRACT**

A Bluetooth headset is disclosed that includes a body having a microphone and an earphone having a Bluetooth module therein; an ear hook having a curved shape, fixed to the body, and worn on a user's ear; and an antenna module disposed to the ear hook. The antenna module includes an antenna radiator mounted inside the ear hook; and an electrical connection element which is electrically connected to the antenna radiator, is drawn out from one connection end of the body of the ear hook, and is power-fed by the Bluetooth module included in the body.



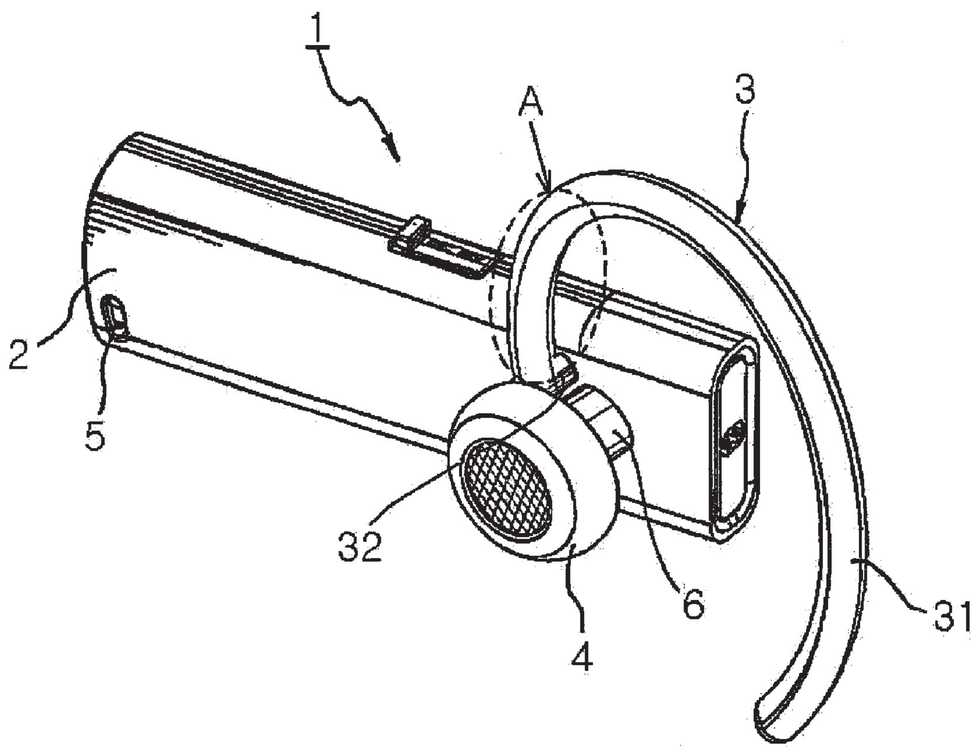


FIG. 1

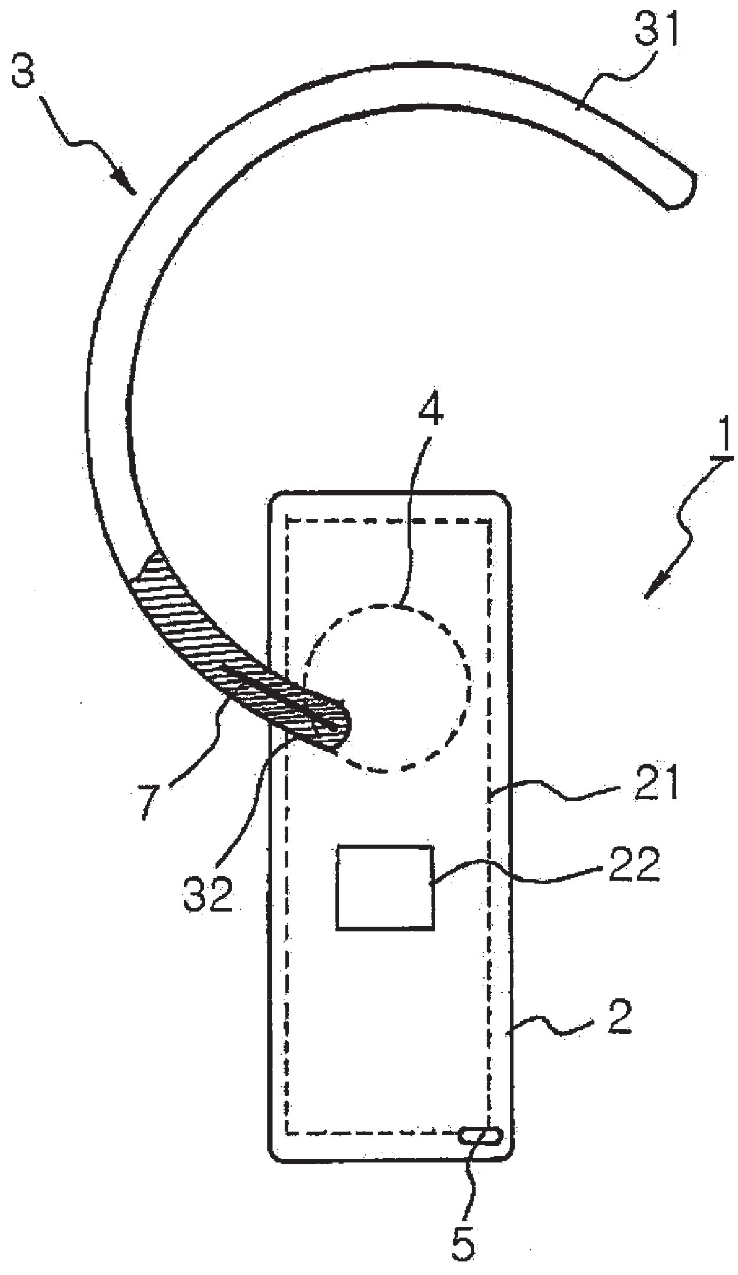


FIG.2

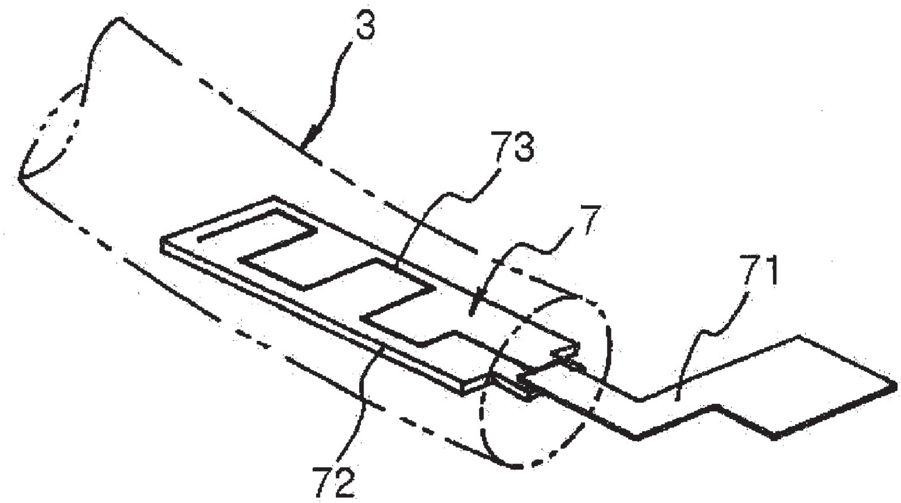


FIG.3

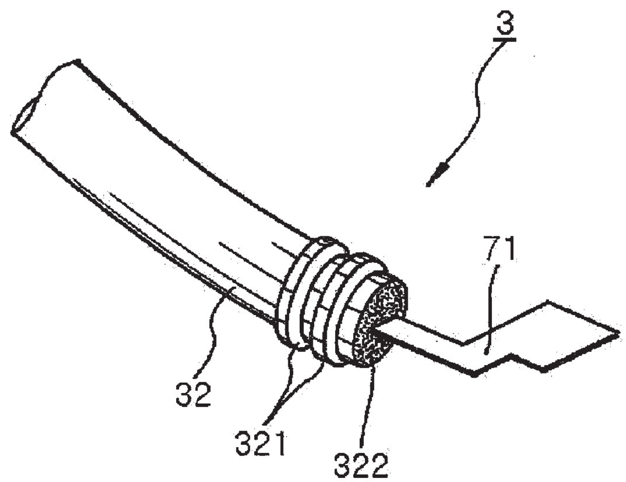


FIG.4

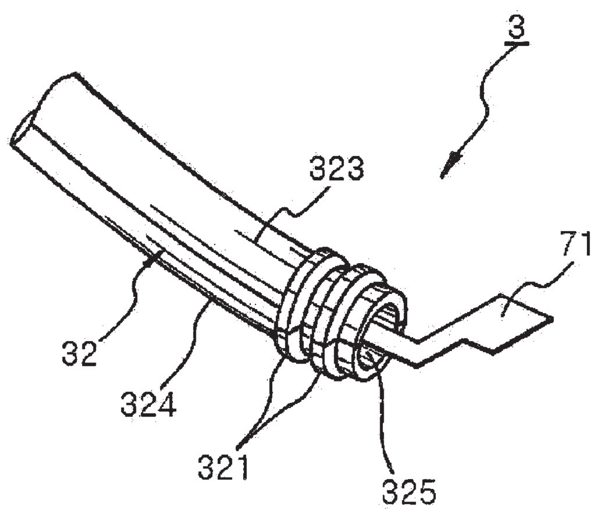


FIG.5

BLUETOOTH HEADSET WITH BUILT-IN ANTENNA MODULE

PRIORITY

[0001] This application claims priority under 35 U.S.C. § 119 to an application filed in the Korean Intellectual Property Office on Nov. 13, 2006 and assigned Serial No. 2006-111542, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a Bluetooth® (hereinafter "Bluetooth") headset with a built-in antenna module, and, in particular, to a Bluetooth headset with a built-in antenna module to provide a slim-sized headset by effectively utilizing a space for mounting the antenna module without affecting functions of the antenna module.

[0004] 2. Description of the Related Art

[0005] The development of a variety of electronic communication industries has resulted in a widespread use of portable terminals. To satisfy user demand, the portable terminals must provide multiple-functions while decreasing size and weight, promoting the development of peripheral devices attached or added to a portable terminal. Examples of the peripheral devices include a camera provided in an attachable manner or in a built-in manner, a smart card provided as an auxiliary memory, an ear-microphone equipped in the portable terminal to be used for a communication purpose, and a Bluetooth headset by which communication is wirelessly achieved by the aid of a Bluetooth module included in the portable terminal.

[0006] In addition to a communication main antenna device, a portable terminal having a Bluetooth function includes an independent Bluetooth antenna module for operating in a frequency band of 2.4 GHz. The Bluetooth module is mounted on a main board of the portable terminal so as to communicate with a Bluetooth headset through a Wireless Local Area Network (WLAN).

[0007] Since a portable terminal employing the Bluetooth headset is used in a hands-free manner, there is no need to connect an additional cable to the portable terminal, thereby facilitating convenience in use of the portable terminal. In addition, the portability of the Bluetooth headset is better than that of a general hands-free wired ear-microphone.

[0008] The Bluetooth headset includes an antenna radiator to communicate with a portable terminal through a WLAN. Conventionally, one or more Surface Mount Device (SMD) type chip-antennas are mounted on a circuit board of the headset. In general, a chip-antenna is constructed with a coil wound a certain number of turns so as to resonate at a specific frequency band.

[0009] However, the conventional Bluetooth headset having the aforementioned structure has a problem in that, since the antenna radiator is disposed on the circuit board included in the headset, a space for mounting the antenna is additionally required, which adversely affects the realization of a slim sized headset.

SUMMARY OF THE INVENTION

[0010] The present invention provides a Bluetooth headset with a built-in antenna module capable of performing a desired function without having to providing an extra space for mounting the antenna module inside the headset.

[0011] The present invention also provides a Bluetooth headset with an antenna module having a structure in which the antenna module is not disposed on a circuit board of the headset, thereby facilitating the realization of a slim-sized headset.

[0012] According to one aspect of the present invention, there is provided a Bluetooth headset with a built-in antenna module, including a body having a microphone and an earphone and including a Bluetooth module therein; an ear hook having a curved shape, fixed to the body, and worn on a user's ear; and an antenna module disposed to the ear hook, wherein the antenna module includes an antenna radiator mounted inside the ear hook; and an electrical connection element which is electrically connected to the antenna radiator, is drawn out from one connection end of the body of the ear hook, and is power-fed by the Bluetooth module included in the body.

[0013] Since the antenna module is not included in the body of the Bluetooth headset, an extra space for mounting the antenna module is not necessary. Therefore, this space can be used to mount other electrical components without increasing the size of the headset, thereby facilitating the realization of a slim-sized headset.

[0014] Preferably, the Bluetooth antenna module of the present invention employs the ear hook as a fixing element of the headset, wherein the ear hook is fixed to the headset to be worn on the user's ear. The ear hook is sufficient in the use of an antenna radiator having a length of $\lambda/4$ and operating at a frequency band of 2.4 GHz.

[0015] Preferably, the antenna module of the present invention can vary depending on the material and the configuration of the ear hook. The antenna module is in a preferred embodiment fixed to the ear hook by insert-molding. In a preferred embodiment, a cavity is formed in the hear hook so that the antenna module can be fixed inside the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

[0017] FIG. **1** is a perspective view of a Bluetooth headset according to the present invention;

[0018] FIG. **2** is a schematic cross-sectional view of a Bluetooth headset with a built-in antenna module according to the present invention;

[0019] FIG. **3** illustrates a built-in antenna module assembled with an ear hook according to the present invention;

[0020] FIG. **4** is a perspective view of an ear hook using an antenna according to an embodiment of the present invention; and

[0021] FIG. **5** is a perspective view of an ear hook using an antenna according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Preferred embodiments of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well-known func-

tions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

[0023] FIG. **1** is a perspective view of a Bluetooth headset according to the present invention and FIG. **2** is a schematic cross-sectional view of a Bluetooth headset with a built-in antenna module according to the present invention. Referring to the figures, the Bluetooth headset includes a body **2** and an ear hook **3** protruding from the body **2** with a certain radius of curvature.

[0024] Although the body **2** is shown in a preferred embodiment having a rectangular shape in the figures, the shape of the body **2** is not limited thereto. Thus, the body **2** may have other various shapes in practice. A microphone **5** is disposed to one end of the body **2**. The other end of the body **2** is provided with an earphone **4** protruding from a neck portion **6**. Preferably, the microphone **5** and the earphone **4** can be separated from each other as far as possible to avoid mutual interference therebetween. As shown in FIG. **2**, a circuit board **21** is included in the body **2**, and a Bluetooth module **22** is mounted on the circuit board **21** to communication with surrounding terminals through a Wireless Local Area Network (WLAN). An antenna module (or antenna radiator) **7** is disposed to an outer portion of the body **2** and is power-fed by the Bluetooth module via an electrical connection element.

[0025] The ear hook **3** is preferably formed to have a specific radius of curvature to be properly positioned in the body **2**. The ear hook **3** has a shape that can be worn on the user's ear. Preferably, the ear hook **3** is disposed to the body **2** in a portion around the earphone **4**. Although the ear hook **3** may be fixedly disposed to the body **2**, more preferably, the ear hook **3** is rotatably disposed to the body **2** so that, when it is not used, the ear hook **3** can rotate properly to minimize a total size of a Bluetooth headset **1**, thereby facilitating the portability of the Bluetooth headset **1**.

[0026] The ear hook **3** includes a hook portion **31** having a specific radius of curvature to be worn on the user's ear and a fixing portion **32** fixed to the body **2**. The hook portion **31** and the fixing portion **32** are formed in an integral manner. Preferably, in order to use the antenna module **7** of the present invention, a portion of the ear hook **3** proximal to the neck portion **6** is made of a rigid or flexible synthetic resin material.

[0027] The built-in antenna module **7** is provided to achieve Bluetooth communication according to the present invention and is included in the ear hook **3**. Preferably, the antenna module **7** is disposed to a portion "A" indicated by a dotted line in FIG. **1**. The portion A is defined as a portion where the body **2** and the ear hook **3** are fixed. When the antenna module **7** is disposed to the portion A, the electrical connection element to be described below can be easily introduced into the body **2**.

[0028] FIG. **3** illustrates the built-in antenna module **7** assembled with the ear hook **3** wherein the antenna module **7** is fixedly mounted inside the ear hook **3** at one end portion of the ear hook **3**.

[0029] Referring to FIG. **3**, the radiator of the antenna module **7** fixed to the ear hook **3** is constructed to form a pattern **73** on a circuit board **72** to have a specific form. Preferably, in FIG. **3**, the circuit board **72** is fixed inside the ear hook **3**. A Flexible Printed Circuit (FPC) **71** is in a preferred embodiment used as the electrical connection element. One end of the FPC **71** is electrically connected to the pattern **73** at one end of the circuit board **72** preferably by soldering. The other end of the FPC **71** is drawn out of the ear hook **3** by a sufficient length. The drawn portion is inserted into the body **2** and is thus electrically power-fed by the Bluetooth module.

[0030] However, the present invention is not limited thereto. For example, as the antenna radiator, only one metal radiation plate may be provided inside the ear hook **3**, wherein the metal radiation plate has a specific pattern according to a specific slot. Besides the FPC **71**, a fine-wire cable may also be used as the electrical connection element.

[0031] As will be described below, the antenna radiator and the electrical connection element may vary depending on the configuration of the ear hook **3** which will be now described.

[0032] FIG. **4** is a perspective view of the ear hook **3** using an antenna according to an embodiment of the present invention. In FIG. **4**, only the fixing portion **32** of the ear hook **3** is depicted. A body fixing portion **321** enables the ear hook **3** to be fixed to the body **2**.

[0033] Referring to FIG. **4**, if the ear hook **3** is constructed of one injection-molded product, the antenna radiator of the present invention may be constructed such that the radiator can be inserted by insert-molding when an injection-molding process is carried out. Preferably, in this process, one end of the FPC **71** protrudes out of the ear hook **3** by a length that is sufficient for the antenna radiator to be inserted into the body **2**.

[0034] FIG. **5** is a perspective view of the ear hook **3** using an antenna according to another embodiment of the present invention. In FIG. **5**, the ear hook **3** is constructed of an upper case frame **323** and a lower case frame **324** which are bonded with each other.

[0035] Referring to FIG. **5**, a cavity **325** is formed when the upper and lower case frames **323** and **324** constituting the ear hook **3** are bonded with each other. The antenna radiator according to the present invention is inserted into the cavity **325** so as to be fixed therein. Although not shown, the antenna radiator is fixed inside the cavity **325**. For example, when using a circuit board having a radial pattern, the antenna radiator is fixed utilizing a bushing formed in the injection-molding process of the upper and lower case frames **323** and **324**. When one metal radiation plate is used, in addition to using the bushing, the antenna radiator may be fixed by utilizing a filling material such as epoxy foam after placing the metal radiation plate to an inner portion of the cavity **325**. In the present invention, it is important that the antenna radiator is disposed inside the ear hook **3**.

[0036] As described with reference to FIG. **4**, the body fixing portion **321** is also used to fix the ear hook **3** to the body **2**.

[0037] According to a Bluetooth headset of the present invention, since an antenna module is included in an ear hook, an extra space for mounting the antenna module is not necessary in a headset body. Therefore, there is an advantage in that the Bluetooth headset can be manufactured in a slim size.

[0038] While the invention has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. Therefore, the scope of the invention is defined not by the detailed description of the invention but by the appended claims, and all differences within the scope will be construed as being included in the present invention.

What is claimed is:

1. A Bluetooth headset with a built-in antenna module, comprising:

a body having a microphone and an earphone with a Bluetooth module therein;

an ear hook that is fixed to the body and worn on a user's ear; and

an antenna module disposed to the ear hook and electrically connected to the Bluetooth module.

2. The Bluetooth headset of claim **1**, wherein the antenna module includes:

an antenna radiator mounted inside the ear hook, and

an electrical connection element which is electrically connected to the antenna radiator, is drawn out from one connection end of the body of the ear hook, and is power-fed by the Bluetooth module included in the body.

3. The Bluetooth headset of claim **2**, wherein the ear hook includes a hook portion having a specific radius of curvature and a fixing portion fixed to the body of the headset, and

wherein the antenna radiator is disposed inside the hook portion of the ear hook.

4. The Bluetooth headset of claim **3**, wherein the ear hook is made of a synthetic resin material.

5. The Bluetooth headset of claim **4**, wherein the antenna radiator is insert-molded by subjecting the ear hook to an injection-molding process.

6. The Bluetooth headset of claim **4**, wherein the ear hook is constructed of an upper case frame and a lower case frame, and

wherein the antenna radiator is mounted in a cavity formed by the upper and lower case frames.

7. The Bluetooth headset of claim **2**, wherein the electrical connection element is a Flexible Printed Circuit (FPC) or a fine-wire cable of which one end is electrically connected to the antenna radiator and another end is electrically power-fed by the Bluetooth module included in the body.

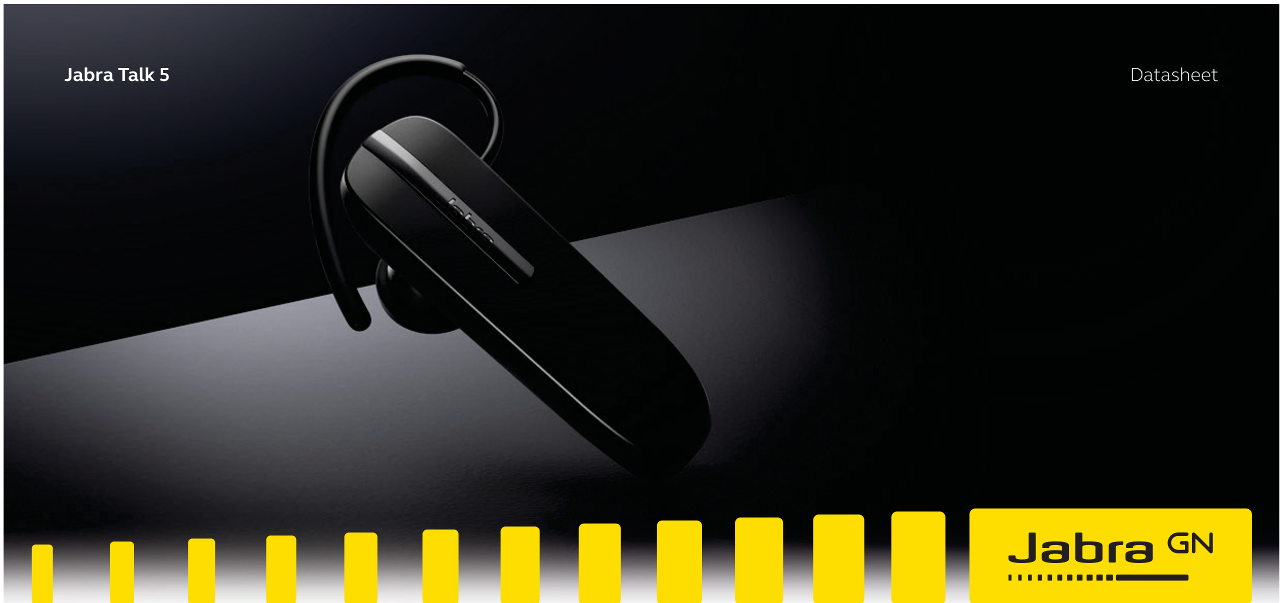
8. The Bluetooth headset of claim **2**, wherein the antenna radiator is a metal plate having a specific shape.

9. The Bluetooth headset of claim **8**, wherein the electrical connection element is electrically connected to one end of the metal plate by soldering.

10. The Bluetooth headset of claim **2**, the antenna radiator has a pattern formed on a dielectric circuit board having a specific shape with a specific width.

11. The Bluetooth headset of claim **10**, wherein the electrical connection element is soldered to electrically connect to one end of the pattern formed on the dielectric circuit board.

* * * * *



Jabra Talk 5
Engineered to keep conversations simple.

Calls made clear
Enjoy calls with a high-quality microphone and speaker that are optimized to make your conversations sound clean and clear.

Easy to use
The Talk 5 features an intuitive design that makes pairing to your phone simple, and making and taking calls easy. Wear with or without an earhook for a comfortable fit.

Long lasting wireless calls
Get the most out of your busy schedule with up to 11 hours of battery, and make reliable Bluetooth wireless calls throughout the day on a single charge.

At a glance:
Jabra Talk 5

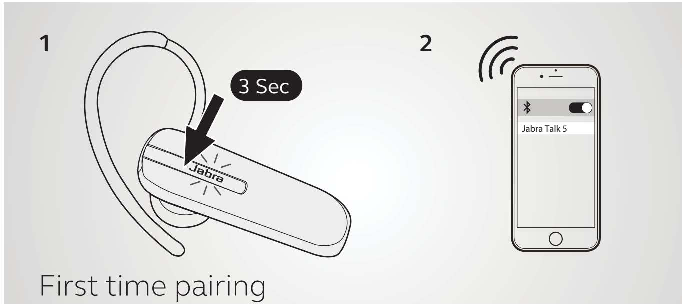
- **Clear calls.** Audio technology optimized for high quality calls.
- **Easy to use.** Simple phone pairing and easy to operate.
- **Long lasting.** Up to 11 hours of wireless calls on a single charge.

GN Making Life Sound Better

Jabra.com/Talk5

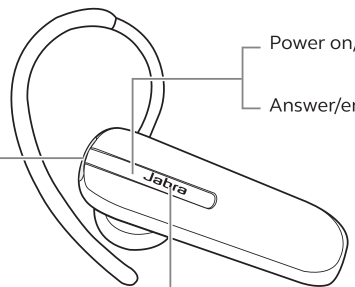
APPLE 1027
Apple v. Koss
IPR2021-00305

How to pair



1. Press and hold the Multi-function button until the LED is blue.
2. Turn on Bluetooth on your smartphone and select the Jabra Talk 5 from the list of available devices.

How to use



Note: Fully charge the headset before first use.

	Features	Benefits	Jabra Talk 5
Audio	Audio technology optimized for high quality calls	Crystal clear call quality	•
Connectivity	Bluetooth®	Wireless connection	•
	MultiUse™	Connects to 2 Bluetooth devices simultaneously	•
	Auto pairing	Automatically connects at 1st time start-up	•
Ease of use	Ultimate Comfort Eargels	All-day perfect fit	•
	Up to 11 hours of talk time	Stay connected all day	•
	Smart functions	Answer call, End call, Reject call*, Voice dialing*, Last number redial*, Call waiting*, Put call on hold*,	•
Compatility		For compatibility information go to **Jabra.com**	

*Device dependant

PATENT

U.S. District Court [LIVE]
Western District of Texas (Waco)
CIVIL DOCKET FOR CASE #: 6:20−cv−00665−ADA

KOSS Corporation v. Apple Inc
Assigned to: Judge Alan D Albright
Related Cases: 6:20−cv−00661−ADA
6:20−cv−00662−ADA
6:20−cv−00663−ADA
6:20−cv−00664−ADA
6:21−cv−00089−ADA
6:21−cv−00091−ADA
6:21−cv−00088−ADA
6:21−cv−00092−ADA
Cause: 35:271 Patent Infringement

Date Filed: 07/22/2020
Jury Demand: Plaintiff
Nature of Suit: 830 Patent
Jurisdiction: Federal Question

Plaintiff

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Date Filed	#	Docket Text
03/24/2020	10	STANDING ORDER from U.S. District Judge Alan D. Albright regarding scheduled civil hearings. Signed by Judge Alan D Albright. (Attachments: # 1 Supplemental Standing Order from Chief Judge Garcia re COVID19 Court Procedures)(mc5) (Entered: 07/24/2020)
07/22/2020	1	COMPLAINT (Filing fee $ 400 receipt number 0542−13787985), filed by KOSS Corporation. (Attachments: # 1 Civil Cover Sheet, # 2 Exhibit A, # 3 Exhibit B, # 4 Exhibit C, # 5 Exhibit D, # 6 Exhibit E, # 7 Exhibit F, # 8 Exhibit G, # 9 Exhibit H, # 10 Exhibit I, # 11 Exhibit J)(Ghavimi, Darlene) (Entered: 07/23/2020)
07/22/2020		Case assigned to Judge Alan D Albright. CM WILL NOW REFLECT THE JUDGE INITIALS AS PART OF THE CASE NUMBER. PLEASE APPEND THESE JUDGE INITIALS TO THE CASE NUMBER ON EACH DOCUMENT THAT YOU FILE IN THIS CASE. (bw) (Entered: 07/23/2020)
07/23/2020	2	REQUEST FOR ISSUANCE OF SUMMONS by KOSS Corporation. (Ghavimi, Darlene) (Main Document 2 replaced on 7/23/2020) (bw). (Entered: 07/23/2020)
07/23/2020	3	Notice of Filing of Patent/Trademark Form (AO 120). AO 120 forwarded to the Director of the U.S. Patent and Trademark Office. (Ghavimi, Darlene) (Main Document 3 replaced on 7/23/2020) (bw). (Entered: 07/23/2020)
07/23/2020	4	Certificate of Interested Parties by KOSS Corporation. (Ghavimi, Darlene) (Entered: 07/23/2020)
07/23/2020	5	MOTION to Appear Pro Hac Vice by Darlene Ghavimi *for Benjamin J. Weed* (Filing fee $ 100 receipt number 0542−13787994) by on behalf of KOSS Corporation. (Ghavimi, Darlene) (Main Document 5 replaced on 7/23/2020) (bw). (Entered: 07/23/2020)
07/23/2020	6	MOTION to Appear Pro Hac Vice by Darlene Ghavimi *for Philip A. Kunz* (Filing fee $ 100 receipt number 0542−13787995) by on behalf of KOSS Corporation. (Ghavimi, Darlene) (Main Document 6 replaced on 7/23/2020) (bw). (Entered: 07/23/2020)
07/23/2020	7	MOTION to Appear Pro Hac Vice by Darlene Ghavimi *for Erik Halverson* (Filing fee $ 100 receipt number 0542−13787996) by on behalf of KOSS Corporation. (Ghavimi, Darlene) (Main Document 7 replaced on 7/23/2020) (bw). (Entered: 07/23/2020)
07/23/2020	8	MOTION to Appear Pro Hac Vice by Darlene Ghavimi *for Peter E. Soskin* (Filing fee $ 100 receipt number 0542−13787997) by on behalf of KOSS Corporation. (Ghavimi, Darlene) (Entered: 07/23/2020)
07/23/2020	9	Summons Issued as to Apple Inc. (bw) (Entered: 07/23/2020)
07/24/2020		Text Order GRANTING 5 Motion to Appear Pro Hac Vice. Before the Court is the Motion for Admission Pro Hac Vice. The Court, having reviewed the Motion, finds it should be GRANTED and therefore orders as follows: IT IS ORDERED the Motion for Admission Pro Hac Vice is GRANTED. IT IS FURTHER ORDERED that Applicant, if he/she has not already done so, shall immediately tender the amount of $100.00, made payable to: Clerk, U.S. District Court, in compliance with Local Rule AT−I (f)(2). Pursuant to our Administrative Policies and Procedures for Electronic Filing, the attorney hereby granted to practice pro hac vice in this case must register for electronic filing with our court within 10 days of this order. entered by Judge Alan D Albright. (This is a text−only entry generated by the court. There is no document associated with this entry.) (jy) (Entered: 07/24/2020)

**IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF TEXAS
AUSTIN DIVISION**

KOSS CORPORATION, *Plaintiff,*	§ § §	
v.	§	**6-20-CV-00665-ADA**
APPLE INC., *Defendant.*	§ § § §	

CLAIM CONSTRUCTION ORDER

The Court provided its preliminary constructions on April 22, 2021. The Court held a claim construction hearing on April 23, 2021, during which the Court heard argument on the claim terms: "a remote, network-connected server that is in wireless communication with the mobile, digital audio player" ('025 Patent – claim 1) ('934 Patent – claims 1 and 58); "in a second audio play mode, the earphones play audio content streamed from the remote, network-connected server" ('025 Patent – claims 2, 12, 21, 30, and 42) ('934 Patent – claims 2, 15, 24, 36, and 59) ('982 Patent – claim 3); "upon activation of the microphone by the user, data are transmitted about the headphone assembly to a remote device" ('025 Patent – claims 8, 18, 27, 36, and 48) ('934 Patent – claims 7, 21, 30, 45, and 61); "host servers" ('451 Patent – claims 1 and 18); "a passive, wireless rechargeable power source" ('982 Patent – claim 17) ('325 Patent – claims 8 and 17). ECF No. 77.

After careful consideration of the parties' briefs, oral argument, and the applicable law, the Court enters its final constructions for each term as shown below.

Claim Term	Court
"a remote, network-connected server that is in wireless communication with the mobile, digital audio player" ('025 Patent – claim 1)	Plain and ordinary meaning

('934 Patent – claims 1 and 58)	
"the processor is for, upon activation of a user-control of the headphone assembly, initiating transmission of a request to the remote, network-connected server" ('025 Patent – claim 1) ('934 Patent – claims 1 and 58) ('982 Patent – claim 4) ('325 Patent – claim 3)	Plain and ordinary meaning
"in a second audio play mode, the earphones play audio content streamed from the remote, network-connected server" ('025 Patent – claims 2, 12, 21, 30, and 42) ('934 Patent – claims 2, 15, 24, 36, and 59) ('982 Patent – claim 3)	Plain and ordinary meaning
"a signal strength [level] for the second wireless communication link" ('025 Patent – claims 4, 5, 7, 9, 14, 15, 17, 19, 23, 24, 26, 28, 32, 33, 35, 37, 44, 45, 47, 49, and 50) ('934 Patent – claims 4, 6, 8, 12, 13, 17, 18, 20, 22, 26, 27, 29, 31, 38, 40, 41, 44, and 58) ('982 Patent – claims 6 and 11) ('325 Patent – claims 5 and 11)	Plain and ordinary meaning
"upon activation of the microphone by the user, data are transmitted about the headphone assembly to a remote device" ('025 Patent – claims 8, 18, 27, 36, and 48) ('934 Patent – claims 7, 21, 30, 45, and 61)	Plain and ordinary meaning
"the processor circuits of the headphones are configured to receive firmware upgrades transmitted from a remote network server" ('155 Patent – claim 13) ('934 Patent – claims 1, 9, 46, 62) ('325 Patent – claim 9)	Plain and ordinary meaning
"host servers" ('451 Patent – claims 1 and 18)	Plain and ordinary meaning
"a passive, wireless rechargeable power source" ('982 Patent – claim 17) ('325 Patent – claims 8 and 17)	Plain and ordinary meaning

IT IS SO ORDERED.

SIGNED this 2nd day of June, 2021.

ALAN D ALBRIGHT
UNITED STATES DISTRICT JUDG

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00305
U.S. PATENT NO. 10,506,325

DECLARATION OF JOSEPH C. MCALEXANDER III

August 27, 2021

TABLE OF CONTENTS

1. I, Joseph C. McAlexander III, declare as follows:

2. I have been retained by counsel for Koss Corp. ("Koss") as a technical expert in connection with the *inter partes* review ("IPR") proceeding identified above for U.S. Patent 10,506,325 (the "'325 Patent"). I submit this declaration in support of Koss's response to the petition.

I. BACKGROUND AND QUALIFICATIONS

3. I have a Bachelor of Science in Electrical Engineering from North Carolina State University and have studied neural science at the University of Texas Graduate School of Biomedical Science.

4. Upon completion of my electrical engineering degree in 1969, I was commissioned as an officer in the U.S. Army. For 2 years, I managed the air defense operation for the New England area, which included radar and secure communication channels to aircraft, missile batteries, and U.S. Command. I then commanded a signal battalion in South Korea for 1 year, designing and orchestrating at the division level the first of its kind communication power grid mapping study using AM and FM transmission/reception, among others, and utilizing crypto security transmission/reception methods.

5. I am a Registered Professional Engineer in the state of Texas (Reg. No. 79,454) and am a recognized inventor on thirty-one U.S. patents. I have forty-

nine years of professional experience, during which I designed and analyzed a variety of microcircuits, semiconductors, and control systems, amongst other technologies for Texas Instruments, Inc. and EPI Technologies, Inc. Specifically, I have designed Dynamic Random Access Memories ("DRAMs"), Static Random Access Memories ("SRAMs"), Charged Coupled Devices ("CCDs"), Shift Registers ("SRs"), and a variety of functional circuits, including input/output buffers for addresses and data transmission, decoders, clocks, sense amplifiers, fault tolerant parallel-to-serial data paths for video applications, level shifters, converters, pumps, logic devices, wireless communication systems, and microelectromechanical systems ("MEMs"). I possess significant expertise in operations and manufacturing associated with these technologies, including a sophisticated knowledge of quality control, testing, reliability, and failure analyses.

6. I have conducted high level instruction to design and process engineers and managers at Texas Instruments, among others, in Solid State Device Physics, Semiconductor Processing, Circuit Design Techniques, and Statistical Quality Control Methods. I have also instructed corporate audiences in Effectiveness Training, Japanese Manufacturing Techniques, and problem recognition and solution methods and tools.

7. As part of licensing of my IP circa 2002 – 2004, I negotiated and executed a number of licensing and design programs to provide GPS tracking and transmission of information wirelessly, using paging and CDMA. The technologies included partnerships for skier tracking with Snowtrax, offender tracking with Stellar Technology Enterprises, pet tracking with The Procter & Gamble Company, journalist tracking with CNN, asset tracking with TrackDaddy, and family tracking with Disney, to name a few. I also advised a startup between 2013 and 2018 in peer-to-peer encrypted cellular communication.

8. I have provided consultancy services associated with the aforementioned technologies. My consulting career began with Cochran Consulting, Inc. in 1991. Currently, I am the President of McAlexander Sound, Inc. and the Managing Director of McAlexander Sound Pte Ltd., where I offer such consultancy services and serve as a Technical Advisor for highly-specialized matters. I provide expert witness services for the protection of intellectual property. As an expert witness, I have investigated processes and designs associated with personal computers, peripheral computers, software, and wireless communications systems, including telephones, microprocessors, controllers, memories, programmable logic devices, and other consumer electronics.

9. As part of my work with McAlexander Sound, I have gained intimate experience with sound and lighting systems. I am very familiar with how acoustic speakers operate and the design issues associated with sound systems.

10. A copy of my curriculum vitae is attached as Appendix A hereto.

II. MATERIALS REVIEWED

11. I considered information from various sources in forming my opinions expressed in this declaration. In addition to drawing from over four decades of experience in the field of circuit design and two decades of experience with wireless technologies, I have also reviewed the IPR Petition and its exhibits, including the '325 Patent (APPLE-1001), Rosener (APPLE-1004), Huddart (APPLE-1005), Price (APPLE-1008), the Declaration of Dr. Cooperstock (APPLE-1003), the deposition transcript for Dr. Cooperstock (KOSS-2034), and the Declaration of Nicholas Blair (KOSS-2036). Furthermore, I reviewed Koss's response filed herewith in detail and I agree with its analysis and conclusions regarding the non-obviousness of the '325 Patent. I also reviewed Petitioner's financial statements (KOSS-2037) and an article (KOSS-2038) pertaining to the commercial success of the Powerbeats Pro headphones and agree that they serve as objective indicia of the non-obviousness of the '325 Patent.

Cooperstock relies on the passage from Rosener that the earphones 502, 504 "may further include a clip, earloop, or other suitable securing mechanism." APPLE-1003, ¶82 (citing APPLE-1004, ¶[0030]). However, a POSITA would not have been motivated to add earloops to the earbud-downwardly extending member combination shown in Rosener's Figure 5 for the following reasons.

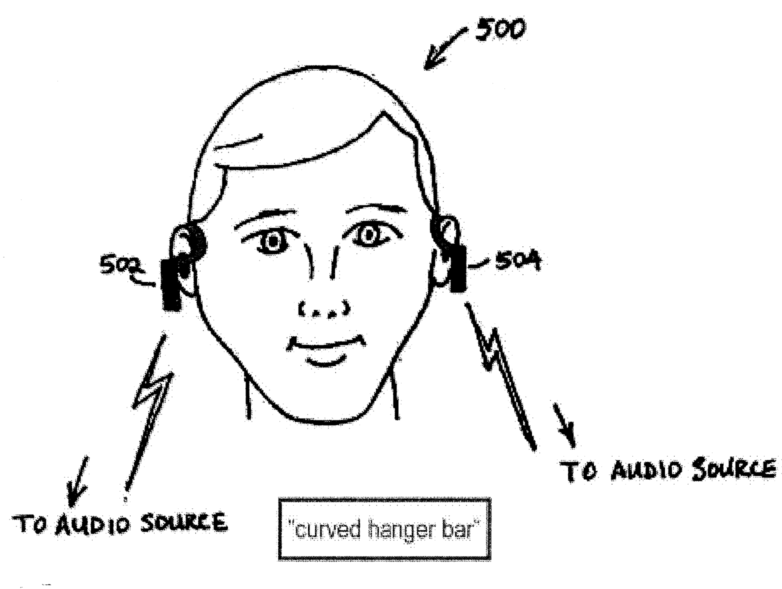

FIGURE 5

APPLE-1004, Figure 5 (annotated/modified to include earloop 404 of Figure 4)

39. After considering information from various sources, including the declaration of Nicholas Blair, it is my opinion that adding an earloop to an earphone with an earbud and a downwardly extending member, as shown in

Rosener's Figure 5, would counteract the securing forces of the earphone's earbud and downwardly-extending member. The earloop in Rosener's Figure 4 counterbalances the extended boom mic that extends to the user's mouth. The downwardly extending member in Rosener's Figure 5 adds weight that pulls the earbud downwardly so that it sits in the user's ear. Adding an earloop to the earbud embodiment shown in Rosener's Figure 5would serve to pry the earbud out of the user's concha and disrupt the overall alignment of the earphone on the user's ear. Simply put, a POSITA would not be motivated to design an earbud that would not be comfortable and stay in the user's ear.

40. Mr. Blair's declaration is clear that, with respect to the earphones depicted in Rosener's Figure 5, the "downwardly-extending member for each earphone is intended to extend through the intratragal notch of the user's ear. … The weight of the downwardly-extending member serves to keep the earbud seated on the lower portion of the concha of the user's ear so that the earbud tends to stay on (or secured in) the user's ear." BLAIR, ¶12. Contrarily, the earloop in Rosener's Figure 4 exerts a force acting on the earphone to hold it in place that is directed toward the back of the ear (*i.e.*, in the opposite direction of the boom mic that would be extending to the user's mouth). BLAIR, ¶14. If the two were combined, that is, the earloop combined with the earbud-downwardly extending

member of Rosener's Figure 5, which is the combination relied upon by the Petitioner and its expert (*See* Pet.at 37; APPLE-1003, ¶84), the result would be a force that "is in a direction that would tend to displace the in-ear portion of the earbud out of the concha, displace the downwardly-projecting member out of the intratragal notch, and/or displace the earloop from around the user's ear. In effect, the ***resultant force would essentially pry the earbud out of the concha***, which would lessen the sound quality characteristics of the earbud and result in earphones that are uncomfortable for the user." BLAIR, ¶16 (emphasis added).

41. For at least this reason, a POSITA would not be motivated to add an earloop to the earbud-downwardly extending member depicted in Rosener's Figure 5. Simply put, a POSITA would not be motivated to modify an earbud in a way that would worsen the performance of the earbud, *e.g.,* by displacing it from the concha, where it is intended to be positioned.

42. Furthermore, contrary to the position of Petitioner, Rosener's description is consistent with this common-sense understanding. Rosener states that the earphones 502, 504 in Figure 5 can take several forms, such as an earbud, a canalphone, or an "over-the-ear circum-aural type headphone… ." APPLE-1004, ¶[0030]. Rosener's Figure 5 appears to show an earbud configuration. An earbud is a tiny speaker that sits in the user's ear. A canalphone is like an earbud but fits

snugly inside the user's ear canal. An "over-the-ear circum-aural type headphone" is a headphone that is worn around the ear ("circum-aural") that fully encompasses the ear ("over-the-ear"). The image below depicts over-the-ear circum-aural type headphones. See www.rtings.com/headphones/learn/over-ear-vs-on-ear-vs-in-ear-vs-earbuds-comparison.

43. Rosener states that the earphones could have various "securing mechanisms," such as a clip or an earloop. *Id.* Rosener, however, never states which listed earphone forms (e.g., earbud, canalphone, or over-the-ear) could also include an earloop. *Id.* The only "earbud" that Rosener discloses with an earloop is the over-the-ear monaural wireless headset shown in Rosener's Figure 4, which headset includes the extended boom mic. The earbuds shown in Rosener's Figure 5 do not include an extended boom mic or an earloop. And based on Mr. Blair's testimony, a POSITA would not add an earloop to the earbud-downwardly extending member depicted in Rosener's Figure 5. Thus, in my opinion, a

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00305
U.S. PATENT NO. 10,506,325

DECLARATION OF NICHOLAS S. BLAIR

I, Nicholas S. Blair, declare as follows:

I. BACKGROUND

1. I am the Director of Product for Koss Corporation ("Koss"). I have been employed by Koss since 2013. My prior position at Koss was Senior Industrial Designer.

2. Prior to my employment at Koss, I worked at:

- RedFusion Studios ("RedFusion") from 2009 to 2013;
- Brooks Stevens Inc. from 2006 to 2010;
- Discovery Channel's Smash Lab from 2007 to 2008;
- Beyond Design, Inc. in 2006;
- Brunswick Corporation in 2005 to 2006; and
- Design Concepts from 2003 to 2005.

3. I received a Bachelor's in Fine Arts from the Milwaukee Institute of Art & Design in 2001, and I studied architecture at the University of Wisconsin-Milwaukee.

4. My professional career has focused on designing products for consumers. Through my employment at both Koss and RedFusion, a significant focus of my work has been on the design of earphones. I am familiar with the design concepts and issues related to all types of earphones, including earbuds, in-ear, on-ear, and over-ear earphones. I have devoted a large portion of my professional career

researching human factors, ergonomics, and human biology as it relates to delivering personal audio in a safe, reliable, and comfortable manner. A core directive, while employed at both Koss and RedFusion Studios, has been to collect expert knowledge in these areas and synthesize the related findings into cohesive personal listening solutions. Ergonomic mockups, CAD simulations, and material-targeted prototyping are all utilized to confirm proper fit, feel, and function of all headphones and earphones during their development phases. Headphone and earphone models that I have developed while under the employment of Koss and RedFusion Studios include the Pro4S, Striva Tap, KPH30i, KE7, KEB25i, KEB9i, and KPH14, among others.

5. I am an inventor of eleven U.S. patents related to consumer audio devices: Patent Nos. 10,1362,10; 10,959,014; 10,531,176; 10,785,550; 10,856,059; 9,628,880; 8,971,555; 10,291,972; 8,861,770; D687417; and 8,737,668.

6. I make this declaration to address specific issues in the "Declaration of Dr. Jeremy Cooperstock" in IPR2021-00305 for U.S. Patent 10,506,325 ("'325 Patent"). In preparing this declaration I reviewed the Declaration of Dr. Jeremy Cooperstock (hereinafter "Cooperstock Declaration," which I understand is exhibit APPLE-1003 in IPR2021-00305) and published U.S. Patent Application Pub. No. 2008/0076489 to Rosener (hereinafter "Rosener," which I understand is exhibit APPLE-1004 in IPR2021-00305).

II. OPINIONS

7. The external anatomy and structure of a human ear is represented in Diagram 1 below. As shown in Diagram 1, a tragus is defined by a ridge of cartilage in front of an external opening of an ear canal. A ridge of cartilage located opposite the tragus defines an antitragus. Just outside of the opening of the ear canal, a bowl-shaped cavity represents a concha. A heel, or intratragal notch, is defined between the tragus and the antitragus at the bottom of the concha bowl.

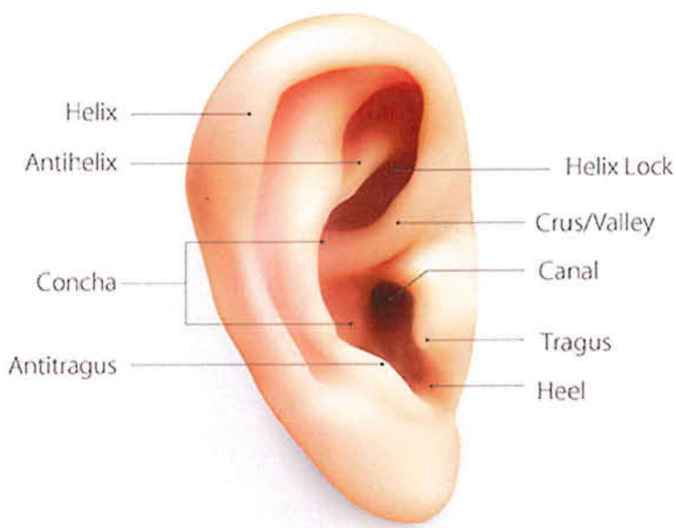

Diagram 1. Ear anatomy. [1]

8. Not depicted in Diagram 1 above, but a term that is used in Rosener, is "pinna." The pinna is the visible portion of the outer ear. Thus, all the portions of

[1] https://www.westone.com/store/hearing_health_care/ear-anatomy

the ear described above are part of the pinna.

9. Figure 4 of Rosener, reproduced below, shows an example of a headphone 402 including "a single audio transceiver for placement ***near the ear*** and a voice tube 406 for directing sound from the user's voice to a microphone within the headphone housing." APPLE-1004, ¶ [0008] (emphasis added). Rosener's "voice tube 406" is conventionally referred to as a "boom mic" because it extends from the headphone 402 to the user's mouth. The headphone 402 further includes a securing mechanism to maintain the headphone 402 near the user's ear. As depicted, the securing mechanism consists of an earloop 404 extending around an outer portion of the user's ear. In such circumstances, the earloop 404 is intended to support the headphone 402 in a position ***near the user's ear***, while balancing the torque from the boom mic 406, so that the headphone 402 is in an orientation that adequately directs a sound emitted from the user's mouth to the boom mic 406.

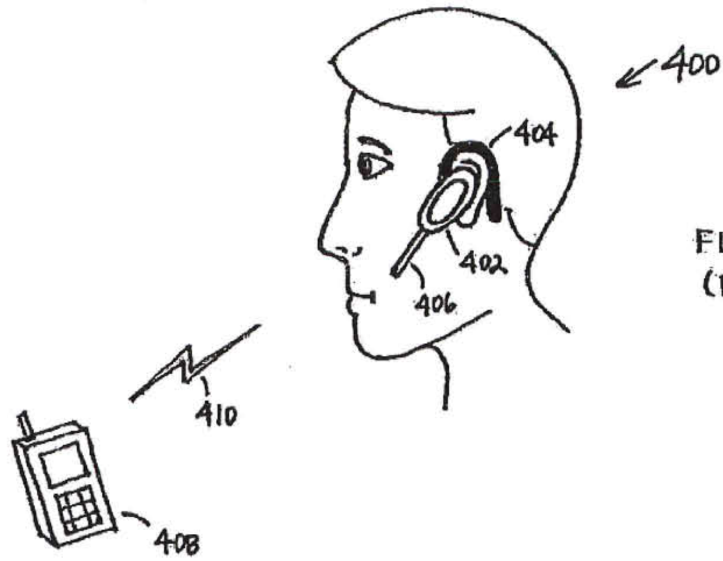

FIGURE 4
(PRIOR ART)

10. The earphone 402 in Rosener's Figure 4 is a wireless earphone. It also only consists of a single earphone. That is, the figure does not depict two earphones 402, one for each ear, and each with the boom mic 406. That is because a user would not want a boom mic extending from each ear on each side of the user's face. I am not aware of any headphones or headsets with two earpieces, where each earpiece has a boom mic extending to the user's mouth on opposite sides of the user's face.

11. Figure 5 of Rosener, reproduced below, depicts a user wearing a pair of wireless earphones 502, 504. Each wireless earphone is "in the form of an earbud designed to fit ***in the concha*** of the pinna of the user's ear." APPLE-1004, ¶ [0030] (emphasis added). The first and second wireless earphones 502, 504 have a securing mechanism to help maintain each earphone 502, 504 on the user's ears. Different

from the securing mechanism of Figure 4, the securing mechanism of the first and second earphones 502, 504 in Figure 5 consists of (1) the earbud in the concha of the pinna of the user's ear and (2) a downwardly-extending member that extends from the earbud portion of the earphone. The downwardly-extending members are not numbered with a reference number in Rosener's Figure 5, but the reproduced Figure 5 is annotated to call them out.

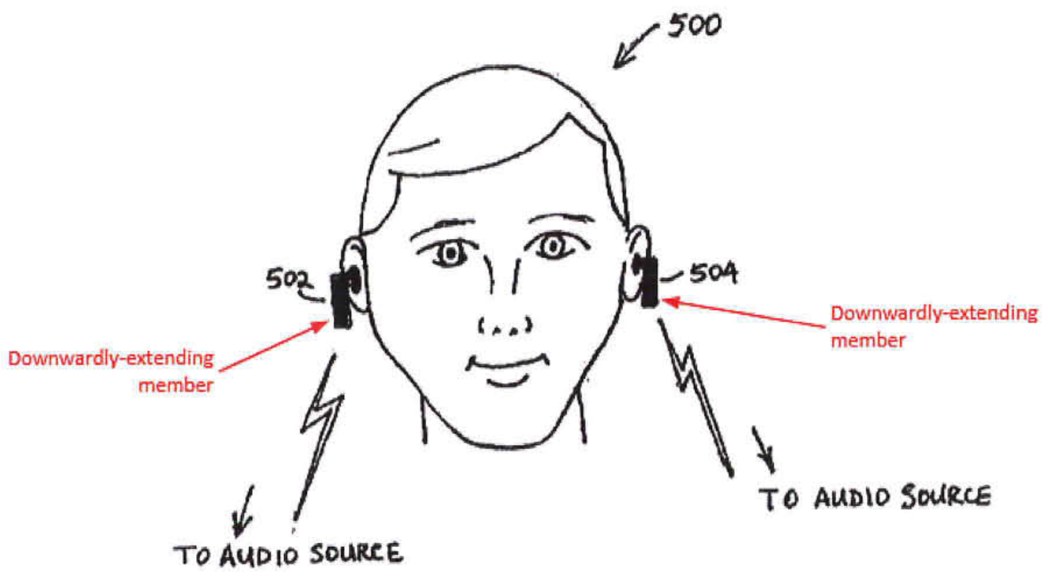

FIGURE 5

12. In such a configuration, the downwardly-extending member for each earphone is intended to extend through the intratragal notch of the user's ear. Stated another way, at least a portion of the downwardly-extending member is sized to be

received in the space defined between the tragus and antitragus of the user's ear. The weight of the downwardly-extending member serves to keep the earbud seated on the lower portion of the concha of the user's ear so that the earbud tends to stay on (or secured in) the user's ear.

13. The Cooperstock Declaration provides a "modified version of Figure 5 showing a configuration of earphones 502, 504 including earloops...." APPLE-1003 at ¶84. The earloops depicted in the Cooperstock Declaration's modified Figure 5, reproduced below, would not work with the earbuds depicted in Rosener's Figure 5. The incorporation of the earloop 404 into the earphones 502, 504 depicted in Rosener's Figure 5, which have the downwardly-extending members, would defeat the purpose of the earbuds' securing mechanism for the configuration shown in Rosener's Figure 4.

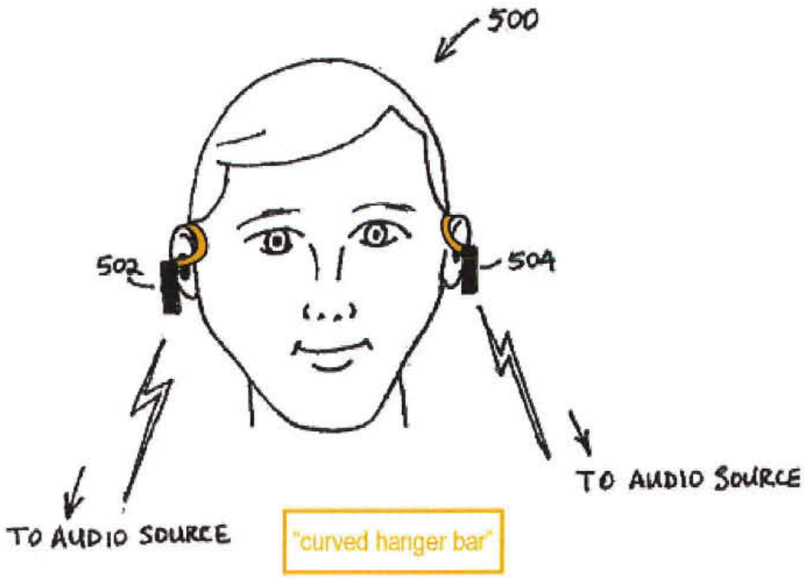

FIGURE 5

14. Each particular securing mechanism applies a specific force vector to an earphone body portion in an effort to maintain the earphone in a desired position on a user's ear. Diagram 2 below is a free-body diagram representing the force(s) acting on the headphone 402 by the earloop 404 to maintain the headphone 402 in its desired position. As shown in this diagram, the forces acting on such a headphone is a force (denoted "$F_{earloop}$") directed toward the upper back of the ear (i.e., in the opposite direction of the boom mic that would be extending to the user's mouth).

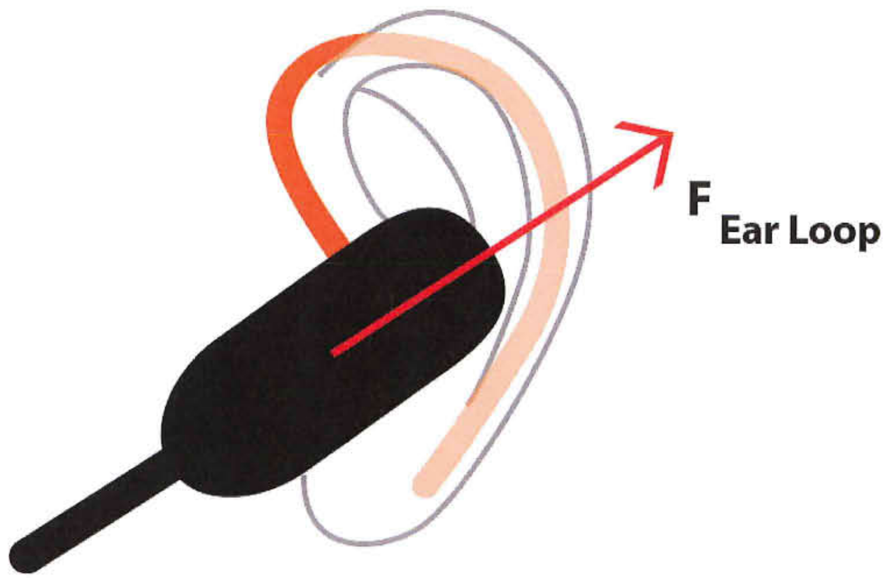

Diagram 2

15. Diagram 3 below, is a free-body diagram representing the force(s) acting on the earphone 502, 504 by the downwardly-projecting member. As shown in Diagram 3, the forces acting on the headphone is a downward force (denoted "$F_{\text{downwardly extending member}}$") acting in the direction of the downwardly extending member.

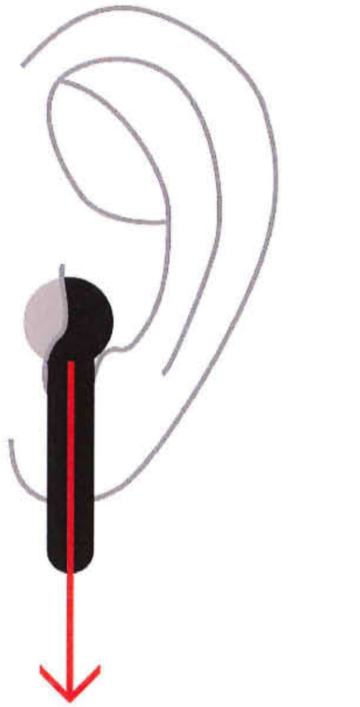

Diagram 3

16. As shown in the free-body diagram depicted in Diagram 4 below, adding an earloop to an earphone already having a downwardly-extending member defeats the purpose of the securing mechanisms for such an earphone. In particular, when the earloop is added to the earphone 502, 504 as shown by the Cooperstock Declaration's modified Figure 5, the individual force vectors (denoted "F_{earloop}" and "$F_{\text{downwardly-extending member}}$" in the diagram below) counteract one another so that the resulting force (denoted "$F_{\text{resultant}}$" in the diagram below) extends in a direction that would tend to displace the in-ear portion of the earbud out of the concha, displace

the downwardly-projecting member out of the intratragal notch, and/or displace the earloop from around the user's ear. In effect, the resultant force would essentially pry the earbud out of the concha, which would lessen the sound quality characteristics of the earbud and result in earphones that are uncomfortable for the user.

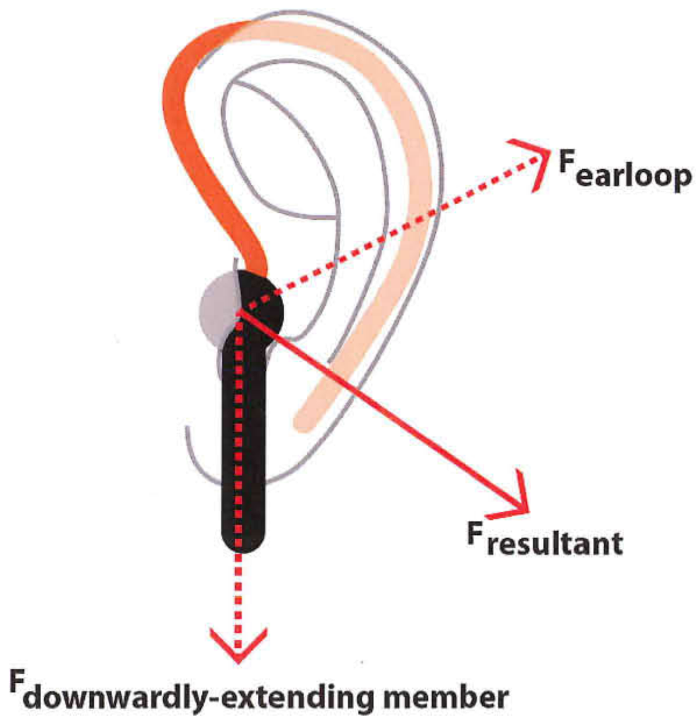

Diagram 4

17. This is why, in my opinion, Rosener does not show earphones having earbuds with both a downwardly-extending member and an earloop. The two would not work together. Nor in my years of experience have I seen earbuds with both a downwardly-extending member and an earloop.

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD
UNITED STATES DISTRICT COURT

APPLE INC.,
Petitioner,
vs.
KOSS CORPORATION,
Patent Owner.

IPR2021-00305
U.S. Patent No. 10,506,325
IPR2021-00381
U.S. Patent No. 10,491,982

Virtual Deposition of JEREMY COOPERSTOCK, Ph.D.
Tuesday, January 18, 2022
11:06 a.m. CST

Job No.: 424006
Pages: 1 - 56
Reported by: Tiffany M. Pietrzyk, CSR RPR CRR

Virtual deposition of JEREMY COOPERSTOCK, Ph.D., pursuant to notice, before Tiffany M. Pietrzyk, a Certified Shorthand Reporter, Registered Professional Reporter, Certified Realtime Reporter, and a Notary Public in and for the State of Illinois.

A P P E A R A N C E S

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C O N T E N T S

E X H I B I T S

(Retained by Counsel)

E X H I B I T S (Cont.)

DEPOSITION EXHIBITS		PAGE
Exhibit APPLE-1030	U.S. Patent Number 7,916,888	50
Exhibit KOSS-2036	Declaration of Nicholas S. Blair	12
Exhibit KOSS-2039	Declaration of Nicholas S. Blair for the '982 patent	42

P R O C E E D I N G S

(Witness sworn.)

WHEREUPON:

JEREMY COOPERSTOCK, Ph.D.,

called as a witness herein, having been first duly sworn, was examined and testified as follows:

EXAMINATION

BY MR. KNEDEISEN:

Q. Hello, Dr. Cooperstock. My name is Mark Knedeisen, representing Koss Corporation.

Just for the record, this is the deposition for IPR2021-00305 for the '325 patent and IPR2021-00381 for the '982 patent.

And if at any time you can't hear my question, just let me know. I'll reask it. Or if you don't understand my question, just let me know, and I will rephrase it if possible. All right?

A. Very good.

Q. Have you ever designed a pair of earphones?

A. Yes.

Q. Could you describe the earphones that you designed?

A. They were fairly simple, using existing components of speakers, wires, power supply.

Q. Were they ever sold commercially?

A. No.

Q. When did you design the earphones you're describing?

A. Sometime in the early 1970s.

Q. Is that the only pair of earphones that you designed?

A. That I can recall at present, yes.

Q. Were the earphones that you designed in the early 1970s wireless earphones?

A. No, they were not.

Q. And can I assume they were not wireless earbuds?

A. You can assume that.

Q. And do you have any patents on headphone design?

A. I do not have any patents on headphones.

Q. Have you ever written any academic papers on headphone design?

A. I would have to go through my publications

hanger bar attaches, nor do I find such a statement in my original declaration.

Q. Well, I thought we already covered this. I mean, earphone 502 in this figure 5, the black portion has what I call a "vertical portion." You said it wasn't vertical, but you called it an "elongated portion"; is that correct?

A. Element 502 has an elongated portion of the earbud.

Q. And is the curved hanger bar connected to the elongated portion?

A. As I stated, neither Rosener nor my declaration makes an explicit statement as to what portion of the earbud the elongated -- the curved hanger bar is attached.

Q. Did you ever construct earphones as depicted in this figure at paragraph 84 of your original declaration?

A. I don't believe I've ever constructed earphones that have that configuration.

Q. Did you ever construct a computer model of the earphones depicted in the diagram of

paragraph 84 of your original declaration?
A. I don't believe I've constructed a computer model of the headphones as depicted in paragraph 84 of my original declaration.
Q. Did you ever compute the center of mass for the earphones as depicted in the diagram in paragraph 84 of your original declaration?
A. I would not be able to do any computation of center of mass without having the relevant parameters of the earphone to carry out that calculation.
Q. Did you perform any mathematical calculations of the forces that would be acting on earphones when worn by a user for the earphones depicted in paragraph 84 of your original declaration?
A. Once again, without having specification of the parameters, the weights of the different elements, the components, the attachment, the coefficient of friction, I would not be able to perform such calculations.
Q. Did you --

A. Once again, the -- this is indeterminate given the illustration and the fact that earbud 4 has a larger diameter than the hook. And I'll note, you know, in addition that the questions you're asking me are not elements or aspects of design that I've considered at all in preparing for the deposition today in that, without parameters being given for the details of the design, the weights, the friction coefficients, and so forth, and the details of positioning of these different elements within the references, I don't have information which allows me to give you answers as to exact positioning and where exactly on the ear these different elements would be placed.

Q. Okay. Thank you. But still referring to figure 1, you referred to a long axis in figure 1; is that correct?

A. The long axis would be going from the left of the page to the right of the page, along the elongated member element.

Q. And does the right end of the elongated member extend past the earbud on the long axis?

A. As shown on the page, the elongated portion extends to the right of earbud 4 -- of the earbud 4.

Q. All right. I want to ask you about Exhibit APPLE-1027 for this IPR, which is the 305 IPR. That's the Jabra Talk 5 exhibit.

Do you remember that one?

A. Yes.

(Exhibit APPLE-1027 was marked for identification was retained by counsel.)

MR. SPROUL: Mark, is this a good time for a break? I think we've been going for about an hour.

MR. KNEDEISEN: It's a good time. Do you want to go off the record?

MR. SPROUL: Sure.

(A short break was had.)

BY MR. KNEDEISEN:

Q. Dr. Cooperstock, I wanted to ask you about Exhibit APPLE-1027 in the 305 IPR, which is about the Jabra Talk 5. Do you have that exhibit?

A. I've got it labeled as 1028, but I believe there was -- remembering at one point this is the "Jabra Talk 5, engineered to keep conversations"

simple on the front. Yeah, same document.

Q. Does the headset depicted in this exhibit include a body portion?

A. Although I haven't described it as such as containing including a body portion in my declaration, it's fair to say that the large semirectangular with curved -- curves rather than corners component, a large portion extending from the top left to the bottom right of the figure on the cover sheet of the exhibit depicts the body portion.

Q. And does the headset depicted in this exhibit include an earbud?

A. Yes, it does.

Q. And is the earbud connected to the semi -- the large semirectangular component that you referred to?

A. It would appear to be, based on the figures, although, since they're all shown from the -- they're shown with the earbud portion occluded or largely occluded by the semirectangular with curved portion elongated member, one cannot be definitive

about it.
Q. Does the elongated portion that's referred to in this exhibit have a long axis?
A. The elongated portion has a long axis, which is along the larger of the two axes. That's why I call it an "elongated portion."
Q. And does the elongated portion extend on the long axis past the earbud on both sides of the elongated portion?
A. Again, based on the limited figures in terms of the constant viewing perspective that they provide, it appears to be the case. But, again, I would hesitate to make definitive statements without seeing more accurate diagrams and, in particular, seeing it from multiple perspectives.
Q. Does the headset depicted in this exhibit include an ear hook?
A. In my supplemental declaration, in paragraph 31, I describe it as including an earloop as a security mechanism.
Q. And is the earloop in the headset depicted in this exhibit connected to the same surface of the

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss, et al.		
U.S. Patent No.:	10,491,982	Attorney Docket No.:	50095-0019IP1
Issue Date:	November 26, 2019		
Appl. Serial No.:	16/528,701		
Filing Date:	August 1, 2019		
Title:	SYSTEM WITH WIRELESS EARPHONES		

Mail Stop Patent Board
Patent Trial and Appeal Board
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT NO. 10,491,982 PURSUANT TO 35 U.S.C. §§311–319, 37 C.F.R. §42

Apple, Inc. ("Petitioner" or "Apple") petitions for *Inter Partes* Review ("IPR") of claims 1-5 and 14-20 ("the Challenged Claims") of U.S. Patent No. 10,419,982 ("the '982 patent").

I. REQUIREMENTS FOR IPR UNDER 37 C.F.R. §42.104

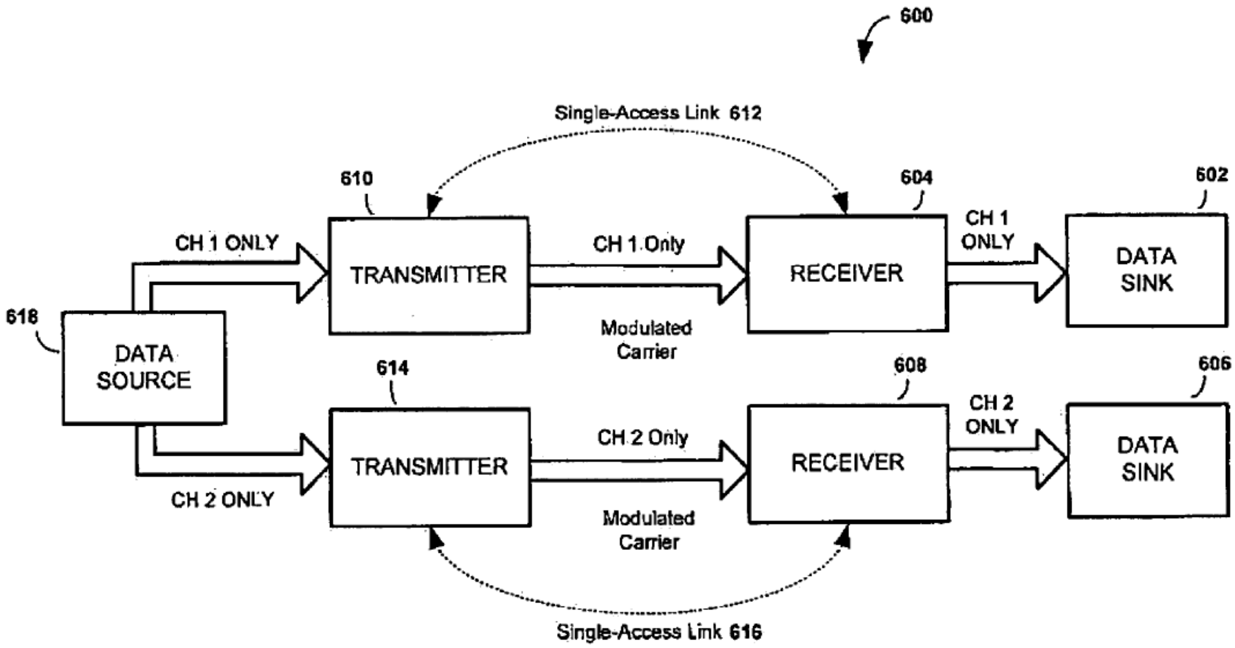
A. Grounds for Standing Under 37 C.F.R. §42.104(a)

Apple certifies that the '982 patent is available for IPR. This petition is being filed within one year of service of a complaint against Apple. Apple is not barred or estopped from requesting this review.

B. Challenge Under 37 C.F.R. §42.104(b) and Relief Requested

Apple requests an IPR on the grounds below. Additional explanation and support for each ground is set forth in the expert declaration of Dr. Cooperstock, referenced throughout this petition.

Ground	Claims	Basis (§103)
1(A)/1(A)(i)	1, 2, 18-20	Rosener and Hankey 1(A) / Rosener, Hankey, and Dyer 1(A)(i)
1(B)/1(B)(i)	3-5	Rosener, Hankey, and Haupt 1(B) / Rosener, Hankey, Dyer, and Haupt 1(B)(i)
1(C)/1(C)(i)	14	Rosener, Hankey, and Price 1(C) / Rosener, Hankey, Dyer, and Price (C)(i)
1(D)/1(D)(i)	15	Rosener, Hankey, and Paulson 1(D) / Rosener, Hankey, Dyer, and Paulson 1(D)(i)
1(E)/1(E)(i)	16, 17	Rosener, Hankey, and Huddart 1(E) / Rosener, Hankey, Dyer, and Huddart 1(E)(i)



APPLE-1004, Figure 6

To enable stereo playback with physical and electrical separateness between the earphones, Rosener describes synchronizing first and second wireless links 612 and 616 to "compensate for differential latencies between the first and second data streams" without requiring any direct communication between earphones, thereby allowing independent operation of each earphone. APPLE-1004, ¶¶[0039-42]; APPLE-1003, ¶39.

2. Hankey

Hankey provides techniques to implement a headset within "a small compact unit". APPLE-1005, ¶¶[0093], [0103]; APPLE-1008, ¶¶[0011], [0093], [0148-150]. The techniques include integrating electronic components/assemblies (e.g., speaker, antenna) into the limited volume of a small headset, by (i) dividing the

indicates that the problem with prior art headsets is that the headsets are either single earpiece monaural devices (e.g., FIG. 4), or are too bulky, requiring wired connections to or between two earpieces to provide stereo sound to a user's ears. APPLE-1004-¶¶[0003-10]; *see id.*, FIGs. 1-4. Rosener's headset is disclosed as being superior to prior art headsets because it is able to provide "high-quality stereo sound" while allowing each of the two earpieces/earphones to be "physically and electrically separated" from the other. APPLE-1004, ¶¶[0010-11], [0030]; APPLE-1003, ¶44. FIG. 5 of Rosener depicts its headset as including two small, wireless compact earphones 502, 504, each of which is physically and electrically separated from the other and is independently in communication with an external audio device (or "audio source") over its own wireless communication link. *Id.*

Rosener, however, is silent as to the implementation details of arranging Rosener's electrical components within the compact form factor of each of the earphones 502, 504, and contains only a limited disclosure of the details of the earphones' form factor. APPLE-1003, ¶45. To implement such earphones, therefore,

---

term "headset" to refer to a single wireless "earpiece" insertable into a user's ear. APPLE-1005, ¶¶[0092], [0107], FIG. 10A. For consistency and to avoid confusion, this petition refers to Hankey's headset as an "earpiece". *See* APPLE-1003, ¶44, (fn 2).

a POSITA would have sought disclosures of small form factors for use in earphones and techniques for arranging electrical components within those earpieces. APPLE-1003, ¶45.

As explained in Section V.A.2, Hankey discloses such small earpieces and techniques. Hankey discloses a compact earpiece capable of communicating with external audio devices wirelessly. Hankey considers the size and weight of prior art headsets as a "key issue" that causes an uncomfortable fit of the headsets on a user's ear. APPLE-1005, ¶[0011]; APPLE-1008, ¶[0003]. To resolve this issue, Hankey provides techniques to package electronics within "a small compact unit" to alleviate the size and shape hassles of conventional headsets. APPLE-1005, ¶¶[0092-98]; APPLE-1008, ¶[0093], ¶¶[0144-150]. Hankey's techniques include dividing the earpiece's electrical assemblies into small groups of electrical components and connecting those small groups to each other by flexible connectors. A POSITA would have been motivated to use Hankey's teachings to implement Rosener's earphones 502, 504, and to arrange components of each of the earphones to fit within the small, compact form factor shown in Rosener's FIG. 5. APPLE-1003, ¶46.

Being aware of Hankey's techniques of implementing a small compact earpiece, a POSITA would have understood that one way to implement each of Ros-

are readily applicable to each of Rosener's earpieces 502, 504 to obtain two small sized earphones capable of providing binaural (e.g., stereo) audio play. APPLE-1003, ¶¶39, 49-50.

Rosener indicates that "[e]ach of the first and second earphones 502, 504 may be in the form of a canalphone[7], which can be fitted within the ear canal of the user's ear." APPLE-1004, ¶[0030]. For the reasons discussed above, a POSITA would have applied Hankey's techniques to implement Rosener's canalphone and, in doing so, arrive at the arrangement of circuit elements recited in the Challenged Claims, as set forth below. APPLE-1003, ¶51.

While the combination of Hankey and Rosener teaches a configuration as recited in the Challenged Claims, to the extent Patent Owner claims that a POSITA would have required additional specificity as to the structure of the portion of the canalphone that is inserted into a user's ear, Dyer provides the necessary teaching. APPLE-1003, ¶54. A POSITA would been motivated to apply the teachings of

[7] The term "canalphone," as used herein, refers to an earphone having a portion that fits within the user's ear canal, as distinguished from, for example, an earphone having an earbud that fits within the concha of the pinna of the user's ear. APPLE-1003, ¶51, (fn 3).

Dyer regarding the ear canal portion to the Rosener canalphones because both describe the same type of earphone – a "canal phone" with an element that extends into the user's ear canal. *Id*.

Based on the teachings of Rosener, Hankey, and Dyer[8], a POSITA would have arrived at a canalphone configuration like that shown, for example, in the following figures. In such a configuration, the Rosener-Hankey canalphone is implemented using Dyer's canalphone elements, including a portion of Dyer's enclosure 115 (which is referred to as the "sub-enclosure 115" herein) that supports intermediary member 111, along with intermediary member 111 and eartip 121. APPLE-1003, ¶¶55-56; *see* APPLE-1006, 2:21-24.

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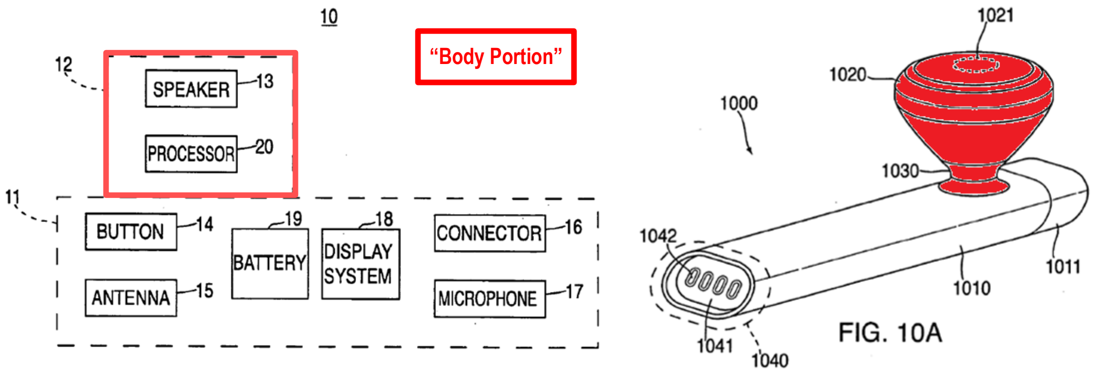
[8] Ground 1(A) of this petition is based on a combination of Rosener and Hankey. Ground 1(A)(i), which adds Dyer to the Rosener-Hanky combination, is offered as an additional ground to the extent further canalphone structural details are deemed necessary.

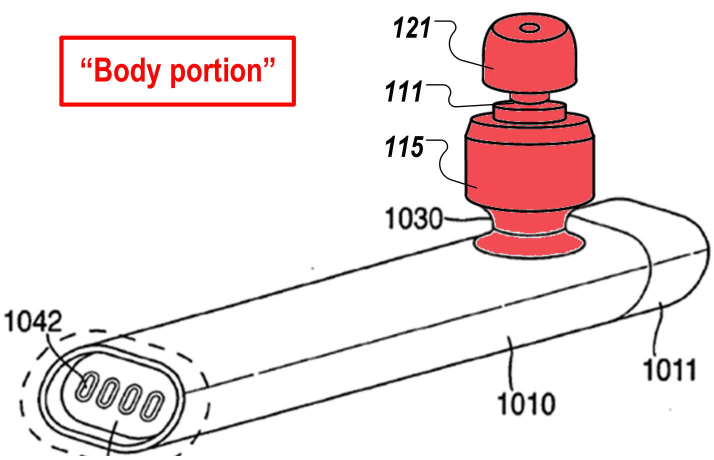


APPLE-1005, FIGs. 1, 10A (annotated).

As explained above, a POSITA seeking to implement Rosener's canalphones would have been motivated to turn to Hankey's teachings to determine how to arrange different electronic components inside Rosener's canalphones. APPLE-1003, ¶96. In doing so, a POSITA would have arrived at, for example, an earphone configuration similar to that of Hankey's earphone but with the earbud replaced by Rosener's ear canal portion. *Id.*; *see* [1.c.i.C].

(i) *Ground 1(A)(i)*

To the extent a POSITA would seek additional implementation details for a canalphone, the POSITA could turn to the teachings of Dyer. In doing so, a POSITA would arrive at a combined Rosener-Hankey-Dyer canalphone, such as the canalphone shown in the following figure, which includes a ***body portion*** containing canalphone elements, including the acoustic components, of Dyer's canalphone. APPLE-1003, ¶97.



The contemplated body portion of each of earphones 502, 504 is highlighted in Rosener's annotated figure 5 below and corresponds to the portion of the housing that contacts a user's ear and is inserted into an ear of user 500 when worn. APPLE-1003, ¶98.

[1.c.i.A] a wireless communication circuit for receiving and transmitting wireless signals;

Rosener discloses that each of earphones 502, 504 includes an RF transceiver circuit (***wireless communication circuit***). APPLE-1004, ¶¶[0011], [0030]. A POSITA would have recognized that a transceiver circuit, by definition, is ***for***

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00381
U.S. PATENT NO. 10,491,982

PATENT OWNER'S UPDATED MANDATORY NOTICES

504300553 v1

Patent Owner, Koss Corporation, submits the following updates to its Mandatory Notices.

I. REAL PARTY-IN-INTEREST

No change.

II. RELATED MATTERS

U.S. Patent No. 10,491,982 ("the '982 Patent") is currently involved in the following lawsuits: Koss Corporation v. PEAG LLC d/b/a JLab Audio, Case No. 6:20-cv-00662 (W.D. Tex.); Koss Corporation v. Skullcandy, Inc., Case No. 6:20-cv-00664 (W.D. Tex); Koss Corporation v. Apple Inc., Case No. 6-20-cv-00665; ~~**and**~~ Apple Inc. v. Koss Corporation, Case No. 4:20-cv-05504 (N.D. Cal.)**; and Koss Corporation v. Skullcandy, Inc., Case No. 2:21-cv-00203 (D. Utah)**.

The '982 Patent is also involved in the following *inter partes* review: *Apple Inc. v. Koss Corporation*, IPR2021-00686, filed March 22, 2021.

The '982 Patent claims priority to PCT application No. PCT/US2009/039754, filed April 7, 2009 (the "PCT Application") and provisional application Serial No. 61/123,265 filed April 8, 2008 (the "Provisional Application"). The following IPRs are also for patents that claim priority to the PCT Application and the Provisional Application: IPR2021-00297 for Patent 10,368,155; and IPR2021-00305 for Patent 10,506,325. Also, IPR2021-00546, filed February 22, 2021 is for a patent (Patent

Trials@uspto.gov
571-272-7822

Paper 15
Date: July 2, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE, INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

IPR2021-00381
Patent 10,491,982 B2

Before DAVID C. McKONE, GREGG I. ANDERSON, and NORMAN H. BEAMER, *Administrative Patent Judges*.

ANDERSON, *Administrative Patent Judge*.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

Apple, Inc. ("Petitioner") filed a Petition requesting *inter partes* review of claims 1–5 and 14–20 of U.S. Patent No. 10,491,982 (Ex. 1001, "the '982 patent"). Paper 2 ("Pet."). Koss Corporation ("Patent Owner") filed a Preliminary Response. Paper 10 ("Prelim. Resp."). Upon our authorization, Petitioner filed a Preliminary Reply relating to discretionary denial based on the factors set forth in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (PTAB Mar. 20, 2020) (precedential) ("*Fintiv*"). Paper 11 ("Prelim. Reply"); *see also* Section III.A below (*Fintiv* analysis). Patent Owner filed a Preliminary Sur-Reply. Paper 12 ("Prelim. Sur-Reply").

We have jurisdiction under 35 U.S.C. § 314. Upon considering the record developed thus far, for reasons discussed below, we institute *inter partes* review.

II. BACKGROUND

A. Real Parties in Interest

Petitioner states it is the real party-in-interest. Pet. 85. Patent Owner states it is the real party in interest. Paper 4 ("Mandatory Notice by Patent Owner"), 1; *see also* Papers 6–9 (Updates to Mandatory Notice).

B. Related Matters

Both parties list the related lawsuit alleging infringement of the '982 patent, *Koss Corporation v. Apple Inc.*, Case No. 6:20-cv-00665 (W.D. Tex.) ("District Court" or "District Court Lawsuit"). Pet. 86. Patent Owner lists the District Court Lawsuit and other lawsuits involving the '982 patent, United States applications to which the '982 patent claims priority, and pending *inter partes* reviews as Related Matters. Paper 9, 1–2.

Haupt, EP 2006/042749 A2, issued Apr. 27, 2006 (Ex. 1020, including English translation).

Petitioner also relies on the Declaration of Dr. Jeremy Cooperstock ("Cooperstock Declaration," Ex. 1003).

F. Prior Art and Asserted Grounds

Petitioner asserts that claims 1–5 and 14–20 would have been unpatentable on the following grounds (Pet. 1–2, 18–85):

Claim(s) Challenged	35 U.S.C. §[6]	Reference(s)/Basis
1, 2, 18–20	103	Rosener, Hankey or Rosener, Hankey, Dyer
3–5	103	Rosener, Hankey, Haupt or Rosener, Hankey, Dyer, Haupt
14	103	Rosener, Hankey, Price or Rosener, Hankey, Dyer, Price
15	103	Rosener, Hankey, Paulson or Rosener, Hankey, Dyer, Paulson
16–17	103	Rosener, Hankey, Huddart or Rosener, Hankey, Dyer, Huddart
17	103	Rosener, Hankey, Huddart, Vanderelli or Rosener, Hankey, Dyer, Huddart, Vanderelli

III. PROCEDURAL ISSUES

Patent Owner alleges the advanced status of the District Court Lawsuit justifies discretionary denial. Prelim. Resp. 1–2. Both parties provided additional briefing on the *Fintiv* factors. *See* Prelim. Reply;

[6] The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. §§ 102 and 103, effective March 16, 2013. Because the application that resulted in the '982 patent has an effective filing date before this date, the pre-AIA versions of §§ 102 and 103 apply.

> because inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known," "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the elements in the way the claimed new invention does.

Personal Web Technologies, LLC v. Apple, Inc., 848 F.3d 987, 991–92 (Fed. Cir. 2017).

B. Level of Ordinary Skill in the Art

Petitioner's expert Dr. Cooperstock, testifies that, based on his experience and the references used to challenge the '982 patent, a person of ordinary skill in the art at the time of the critical date for the '982 patent

> would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks. Superior education could compensate for a deficiency in work experience, and vice-versa.

Ex. 1003 ¶ 30. At this stage of the proceeding, the level of ordinary skill has not been shown as affecting our analysis. Nonetheless, for purposes of this Decision, we adopt Petitioner's proposal as testified to by its expert.

C. Claim Construction

In an *inter partes* review for a petition filed on or after November 13, 2018, a claim "shall be construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 282(b)." For petitions filed on or after November 13, 2018, a claim shall be construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b),

Cooperstock. APPLE-1003. As explained herein, Cooperstock, who has skills and experience superior to a POSITA, could not explain important aspects of the relied-upon prior art including: how Rosener's transducer operates; how Rosener's A/D converter and data buffer coordinate; and what Hankey's flexible circuit would be made of in order to make the combination proposed by Cooperstock. KOSS-2037, 36-43 (transducers), 45-61 (data buffer), 67-68 (material for flexible circuit board). Cooperstock's opinion that the Challenged Claims would have been obvious to a POSITA without skills or experience designing wireless earphones may be explained because that is what Cooperstock does—testify upon request that patent claims are invalid. He has testified in several matters regarding patent validity and every time found that the claims are invalid. APPLE-1003, pp.125-126; KOSS-2037, 87-93. He has never given testimony that a patent claim is valid because he has not "been called on to provide such testimony." KOSS-2037, 93.

III. PETITIONER FAILED TO SHOW THAT INDEPENDENT CLAIM 1 WOULD HAVE BEEN OBVIOUS

A. Petitioner Failed to Show that a POSITA Would Have a Reasonable Expectation of Success Achieving Petitioner's Proposed Combinations

The lynchpin of Petitioner's argument that independent claim 1 would have been obvious over Rosener and Hankey (and Dyer) is:

> Being aware of Hankey's techniques for implementing a small compact earpiece, a POSITA would have understood that one way to implement Rosener's earphones 502, 504 would be to divide the corresponding electronic assemblies of [Rosener's] earphone into two portions, and electrically couple the components in each of the portions by a flexible electrical connector. One portion would be contained within the top part of Rosener's earphone (similar to Hankey's 'earbud'), and the other portion would be contained within a 'longitudinal member' Hankey discloses as extending away from the top portion.… Such a configuration would enable arrangement of components within the form factor of Rosener's small earphones 502, 504.

Pet. at 27 (citing APPLE-1003, ¶47). The evidence, however, shows that such a modification of Rosener in view of Hankey is beyond the skill of a POSITA and, therefore, would not have been obvious. The other grounds (Grounds 1(B)-(E) and Grounds 1(B)(i)-(E)(i)) in the Petition build on Grounds 1(A) and 1(A)(i) for claim 1; they also fail because the underlying argument for claim 1 fails.

1. Skill Level of a POSITA

The Board should adopt Petitioner's assertion that a POSITA "would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks," where "[s]uperior education could compensate for a deficiency in work experience, and vice-versa." APPLE-1003, ¶30; KOSS-2037, 29:14-30:8. Patent

Owner agrees that this is an appropriate skill level for a POSITA for the '982 Patent. KOSS-2038, ¶20. Under this standard, a POSITA can have merely a Bachelor's Degree in computer science and two years of experience in short distance wireless communication or local area networks and no skills or experience specific to sound engineering or wireless headphone technology. While electrical engineering or computer science may provide context for certain underlying principles related to circuitry and signal transmissions, these academic disciplines do not specifically pertain to acoustics, wireless headphones, or even wireless speakers. *Id.* Similarly, short-term experience with short distance wireless communications or local area networks would also not necessarily involve acoustics, wireless headphones or wireless speakers. *Id.* Importantly, among the skills that Cooperstock did not identify that a POSITA would necessarily have are skills or experience related to designing the acoustic transducer for a wireless earphone, fitting all of the components into a small form factor earphone, and powering the device in a manner suitable for a wireless earphone.

2. Modifying Rosener in view of Hankey is Beyond the Skill Level of a POSITA with a Bachelor's Degree in Computer Science and Two Years of Experience with Local Area Networks

Relevant to the '982 Patent, the skills and knowledge of Petitioner's expert (Cooperstock) are superior to the skills and knowledge of a POSITA with a bachelor's degree in computer science and two years of experience with local area

networks. KOSS-2037, 37:7-16. Cooperstock earned a Ph.D. in Electrical and Computer Engineering in 1996. APPLE-1003, ¶7. By the time of his deposition, he had approximately 25 years of industry experience. *Id.*, ¶¶8-11 and pp. 121-126. Yet, Cooperstock could not explain how many of the components in Rosener's and Hankey's headsets operate, including components that are critical to constructing operative wireless earphones. Because a person with superior skills does not understand critical concepts in the relied-upon prior art pertaining to designing wireless earphones, a POSITA with inferior skills and knowledge, such as a POSITA—who may only have a bachelor's degree in computer science and two years of experience with local area networks—also would not understand the concepts in Rosener and Hankey, and could not, therefore, modify Rosener in view of Hankey to arrive at the subject matter of claim 1.

For example, Rosener's earphones include a speaker (or "transducer element"). APPLE-1004, ¶[0030]. Rosener explains that the speaker could be "a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements." *Id.* According to Petitioner, the speaker in the Rosener-Hankey (-Dyer) combination would be contained in the "top part of the earphone" and would be connected to the other components of the earphone by "a flexible

electrical connector" as taught by Hankey. APPLE-1003, ¶47; Pet. at 26-27. Yet Cooperstock, who has skills superior to a POSITA—who may only have a bachelor's degree in computer science and two years of experience with local area networks—could not explain how the speaker elements disclosed in Rosener operate or even how they compare to one another. KOSS-2037, 37:17-43:17. To design and construct operative wireless earphones, the designer would need to select the appropriate transducer design given the sound quality and earphone form factor considerations. KOSS-2038, ¶50.

As described above, Rosener's earphones also include a data buffer and an A/D converter. APPLE-1004, ¶¶[0037]-[0038]. A POSITA with a bachelor's degree in computer science and without industry experience designing wireless headphones would experience difficulty coordinating the operation of these components in the wireless earphones, including their coordination to "compensate for differential latencies between" the data streams for the two earphones. *Id.*, ¶[0039]. Cooperstock's position is that Rosener's A/D converter "take[s] samples out of" the data buffer and "consumes" the data samples in the data buffer, rather than the A/D converter putting the digitized samples into the data buffer. KOSS-2037, 46:3-6 ("my understanding is that an A/D converter that is connected to a buffer will take samples out of that buffer"); 46:6-11 (A/D converter is "taking

samples out of" the data buffer and "passing it on to the next stage in the circuit"); 50:1-6 ("my understanding is that if there's an A/D converter that is consuming content from the buffer, that means the buffer is holding analog information or analog data").

On the other hand, Patent Owner's expert ("McAlexander"), who also has superior skills relative to the '982 Patent than a POSITA with only a bachelor's degree in computer science and two years of experience in local area networks (and without experience designing wireless earphones) (KOSS-2038, ¶¶3-10), interprets Rosener differently. According to McAlexander, Rosener's A/D converter samples (after some processing) the received analog signal. KOSS-2038, ¶54; APPLE-1004, ¶[0047]. The A/D converter, by its very nature, converts an analog signal to digital values. It makes sense, therefore, that the A/D converter would convert an input analog signal to digital values (i.e., data) for storage in the data buffer. KOSS-2038, ¶54. In that connection, a "data buffer" as referred to in Rosener, is normally understood to store digital data, not analog data. Thus, it would make sense that Rosener's data buffers store the outputs of the corresponding A/D converter, not that the A/D converter takes digitized samples out of the data buffer. *Id.*, ¶54.

McAlexander's understanding is consistent with Rosener. Rosener describes that if the A/D converter is too fast, the A/D converter will stall because it will run

out of data faster than data are provided to it. APPLE-1004, ¶[0038]. Thus, with a fast A/D converter, there will be fewer digitized samples to store in the data buffer (because the A/D converter will have stalled), so Rosener proposes techniques (interpolated or repeated data samples) to replenish the data buffer. APPLE-1004, ¶[0039]. That suggests that the output of the A/D converter (i.e., digitized samples) is input to the data buffer for storage. KOSS-2038, ¶55.

Cooperstock's and McAlexander's differing views of Rosener's earphones illustrate the complexity of designing wireless earphones. Two persons (Cooperstock and McAlexander) that both have skills superior to a POSITA with a bachelor's degree in computer science and without industry experience designing wireless headphones, have different views on how Rosener's A/D converter and data buffer would coordinate (or how they would be connected) in order to make an operable wireless earphone. In light of these complexities, it would not have been obvious to a POSITA with a bachelor's degree in computer science and two years of experience with local area networks, and without industry experience designing wireless headphones, to make the combinations proposed by Petitioner for claim 1. KOSS-2038, ¶56. Such a POSITA would have no reasonable expectation of success coordinating the operation of the A/D converter and the data buffer; e.g., should the output of the A/D converter be input to the data buffer, or should the A/D converter

consume the data samples stored in the data buffer? This would require experimentation by the POSITA, and in light of a POSITA's lack of experience designing wireless earphone, the experimentation would be complicated and beyond the POSITA's skill level. KOSS-2038, ¶56. Thus, there would be no reasonable expectation of success for the POSITA in making the combinations proposed by Petitioner. *See Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017) (where "one would no more have expected failure than success is not a valid ground for holding an invention to have been obvious").

Still further, Cooperstock testified that the data source 922 in Rosener's Figure 9 could be a sensor or a microphone. KOSS-2037, 102:10-18. Cooperstock also testified that the data source 922 in Figure 9 is the same as the data source 618 in Rosener's Figure 6. *Id.*, 102:21-103:12 ("they're referring to the same data source"). Rosener's data source 618 may be a digital or audio data source. APPLE-1004, ¶[0033]. If a digital data source, it can be "an MP3 player, CD player, PC, PDA, mobile telephone, game console, component of an entertainment system, etc." *Id.* If Cooperstock, a person having superior skill in the art to a POSITA, cannot ascertain whether data source 922 is a sensor/microphone incorporated into a wireless earphone or is a digital or audio data source like an MP3 player that is external to the wireless earphone, a POSITA would not have a reasonable

expectation of success implementing Rosener's headset within the compact form factor of Hankey. KOSS-2038, ¶68.

Cooperstock also could not identify a suitable material for the flexible electrical connector in the proposed combination. KOSS-2037, 67:1-68:4. Because a person with superior skills did not understand these components of the proposed Rosener-Hankey combination that are critical to making operative wireless earphones, a POSITA that has inferior skills and who has no educational or industry experience designing wireless earphones (KOSS-2037:32:18-20) would have no reasonable expectation of success making wireless earphones with a transducer in the "top part" as proposed by Petitioner. KOSS-2038, ¶48.

In light of the failure of Cooperstock to understand important constituent components of Rosener's and Hankey's earphones that are critical to making operational wireless earphones, a POSITA (including a POSITA with a bachelor's degree in computer science and two years of experience in local area networks, and no experience designing wireless earphones) could not, with a reasonable expectation of success, make the combinations proposed by Petitioner. KOSS-2038, ¶¶49, 52, 56. Thus, claim 1, and all Challenged Claims depending therefrom, would not have been obvious in view of the combinations proposed by Petitioner. *See Eli Lilly and Co. v. Teva Pharms. Int'l GmbH*, 8 F.4th 1331, 1345 (Fed. Cir. 2021) (in

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

Case IPR2021-00381
Patent 10,491,982

PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE

2. *Rosener-Hankey-Dyer Combination Implicates An Operable Design*

Blair Declaration only asserts that the Rosener-Hankey-Dyer canalphone would not be an ideal design. KOSS-2039, ¶¶17, 20. A POSITA at least would have contemplated the proposed design as an operable embodiment, even if it is inferior to other designs regarding how it fits or how long it stays in user's ear. APPLE-1024, ¶¶37-38. As McAlexander testified, a POSITA would have viewed a canalphone to have less tendency to dislodge as compared to an earbud. APPLE-1025, 145:19-146:24. Thus, a POSITA would have recognized that Rosener's disclosure of a canalphone could be implemented in the Rosener-Hankey combination as advanced in the Petition to provide a superior securing mechanism than an earphone configuration, like that disclosed in Hankey. Notably, Koss did not argue that combining the relevant teachings of Rosener and Hankey as in the device recited in the Challenged Claims would have been "uniquely challenging or difficult for one of ordinary skill in the art." *See Leapfrog Enters., Inc. v. Fisher-Price, Inc.*, 485 F.3d 1157, 1162 (Fed. Cir. 2007) (citing KSR, 550 U.S. at 418-19).

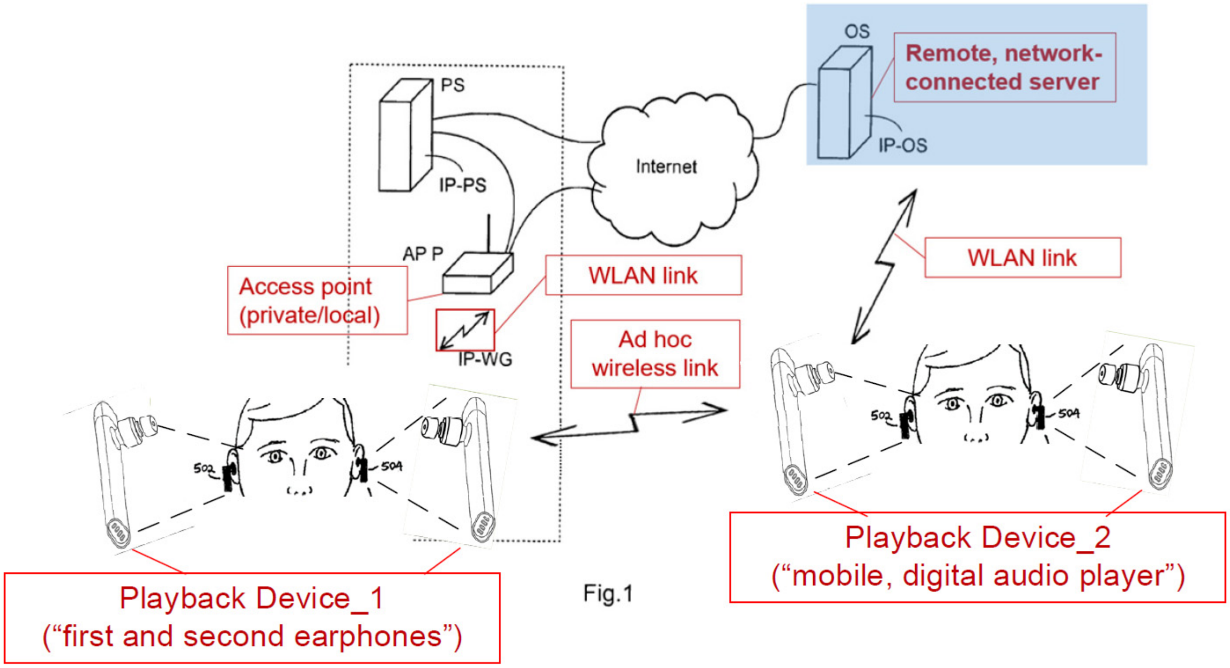
III. ROSENER-HANKEY-HAUPT COMBINATION TEACHES THE "REMOTE NETWORK SERVER" OF CLAIM 4

Koss asserts that Petitioner has not shown that the same remote network server that is in communication with the earphone is also in communication with the mobile digital audio player (DAP) of claim 1. Resp., 48-49. Koss also

purports that the Petition's grounds for claim 4 are deficient for the same reasons that led to non-institution in IPR2021-00546. Resp., 50-51. But KOSS is wrong because it ignores that the Petition applied specific audio forwarding feature for a master/slave configuration of Rosener-Hankey-Haupt combination that were not at-issue in IPR2021-00546. *See* Pet., 61-66.

A. The Petition Discussed A Master/Slave Configuration That Addressed The Features Of Claim 4

In the master/slave configuration discussed in the Petition, the headphone recited in claim 4 is mapped to a slave headphone (or Playback Device_1), and the mobile DAP recited in claim 4 is mapped to a master headphone (or Playback Device_2). Pet., 61-66. The master would then perform "as a local server, providing the stored audio files to the slave." *Id*. As illustrated below, the same remote network server that communicates with the slave (i.e., the headphone), is also in communication with the master (i.e., the mobile DAP). *Id*.; APPLE-1024, ¶¶39-42.



A POSITA would have understood that the master earphone in Haupt is another example of Rosener's data source 618 (which was mapped to mobile DAP in claim 1) because the master earphone is a device that sends audio to another earphone, which is the same function that Rosener lists for data source 618. APPLE-1024, ¶43.

In the context of Rosener's teachings, a POSITA would have also understood that Rosener's data source 618 would be capable of communicating with a remote network server. The examples that Rosener provides for data source 618 would have been generally recognized as devices capable of communicating with a remote network server. APPLE-1024, ¶¶41-44; *see also* Pet., 51 (citing APPLE-1004, ¶[0030]).

B. The Grounds Advanced in This Proceeding Set This Proceeding Apart From IPR2021-00546

The Board should not adopt the rationale used to deny institution in IPR2021-00546 because the grounds of invalidity in each proceeding have substantial differences, including applications of different prior art references.

Further, the above-discussed master/slave configuration was not at-issue in IPR2021-00546. The Petition and Cooperstock's Declaration also elaborated on the benefits of using the master/slave configuration, which was missing in IPR2021-00546. *See* Pet., 67-72; APPLE-1003, ¶¶131-151.

IV. ROSENER-HANKEY-PRICE COMBINATION TEACHES THE FIRMWARE UPGRADE OF CLAIM 14

A. Koss Improperly Imports Teachings from the Specification To Claim 14

Koss focuses on attempting to distinguish claim 14 by improperly importing a system-on-chip (SoC)—that purportedly would have "lower power requirements"—from the '982 patent into the claim language. Resp., 54-55. Claim 14 does not recite any feature corresponding to an integrated circuit or a SoC, much less require one to provide power for firmware upgrades. McAlexander confirmed that the '982 patent specification does not limit implementation of the '982 patent's transceiver circuitry to an SoC. APPLE-1025, 181:11-182:18; 190:20-191:1. Thus, neither claim 14 nor any other part of the 982 specification provides any hint or suggestion that firmware upgrades have a

power

issue that requires an inventive SoC implementation as now asserted by Koss. APPLE-1024, ¶¶45-46.

B. A POSITA Would Have Understood How To Implement The Rosener-Hankey Combination To Avoid Any Power Consumption Issues Relating to Firmware Upgrades

Koss asserts that "updating a device's firmware requires that the device be sufficiently powered." Resp., 53. KOSS then alleges that Rosener's battery would be unreliable for upgrading firmware, and modifying Rosener's earphones based on Hankey's way of powering "would require a substantial modification of Rosener's earphones." *Id*, 53-54. However, Koss does not provide any support for this allegation. APPLE-1024, ¶¶47-48.

First, Koss does not explain its reasoning for assuming an unreliable battery for Rosener. This is not surprising, since Rosener lacks any disclosure indicating that the battery would be unable to provide sufficient power during a firmware upgrade. *See* APPLE-1025, 179:1-180:13 (confirming that Rosener does not address power capability). And, as discussed below, Koss's assumption is also wrong because a POSITA would have understood how to implement configuration options that would have addressed any power consumption issues associated with firmware upgrades. APPLE-1024, ¶¶49-50.

Second, even if Koss were correct that certain types of firmware upgrades involve high power consumption, a POSITA would have known how to implement

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00381
U.S. PATENT NO. 10,491,982

PATENT OWNER'S NOTICE OF APPEAL

To the Director of the United States Patent and Trademark Office:

Notice is hereby given, pursuant to 37 C.F.R. § 90.2(a), that Patent Owner Koss Corporation ("Koss") appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered on June 27, 2022, (Paper 43) ("Final Written Decision") by the Patent Trial and Appeal Board ("the Board"), and from all underlying orders, decisions, rulings, and opinions. A copy of the Final Written Decision is attached as Exhibit A.

In accordance with 37 C.F.R. § 90.2(a)(3)(ii), Koss indicates that the issues on appeal include, but are not limited to, the Board's determination that claims 1-5 and 14-18 (the "Invalidated Claims") of U.S. Patent 10,491,982 B1 ("'982 Patent") are unpatentable over the prior art of record, and any finding or determinations supporting or related to that ruling including, without limitation, the Board's decision that Petitioner showed by a preponderance of the evidence that the Invalidated Claims of the '982 Patent are obvious over the prior art of record and that the Patent Owner failed to show that the commercial success of certain commercial products, the AirPods and AirPods Pro wireless earphones, is a secondary indicia of the nonobviousness of the Invalidated Claims.

Pursuant to 37 C.F.R. § 90.3(a)(1), Patent Owner is timely filing this Notice of Appeal within sixty-three (63) days of the Board's June 27, 2022 Final Written Decision. Pursuant to 37 C.F.R. § 90.2(a)(1), Patent Owner is filing copies of this

Notice of Appeal with the Director of the United States Patent and Trademark Office and with the Board. Pursuant to Federal Circuit Rule 15(a)(1), Patent Owner is filing a copy of this Notice of Appeal with the Clerk of the United States Court of Appeals for the Federal Circuit, and paying the required fees.

Respectfully submitted this 9th day of August, 2022.

K&L Gates, LLP

By: /Mark G. Knedeisen/
Mark G. Knedeisen
Reg. No. 42,747

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss		
U.S. Patent No.:	10,491,982	Attorney Docket No.:	50095-0019IP1
Issue Date:	November 26, 2019		
Appl. Serial No.:	16/528,701		
Filing Date:	August 1, 2019		
Title:	SYSTEM WITH WIRELESS EARPHONES		

DECLARATION OF DR. JEREMY COOPERSTOCK

II. QUALIFICATIONS

6. I am a professor in the Department of Electrical and Computer Engineering at McGill University. My curriculum vitae is provided as Appendix A.

7. I received my B.Sc. in Electrical Engineering from the University of British Columbia, my M.Sc. in Computer Science from the University of Toronto in 1992, and my Ph.D. in Electrical and Computer Engineering from the University of Toronto in 1996.

8. I am a member of the Centre for Intelligent Machines, and a founding member of the Centre for Interdisciplinary Research in Music Media and Technology at McGill University. I also direct the Shared Reality Lab at McGill, which focuses on computer mediation to facilitate high-fidelity human communication and the synthesis of perceptually engaging, multimodal, immersive environments. I led the development of the Intelligent Classroom, the world's first Internet streaming demonstrations of Dolby Digital 5.1, multiple simultaneous streams of uncompressed high-definition video, a high-fidelity orchestra rehearsal simulator, a simulation environment that renders graphic, audio, and vibrotactile effects in response to footsteps, and a mobile game treatment for amblyopia.

9. My work on the Ultra-Videoconferencing system was recognized by an award for Most Innovative Use of New Technology from ACM/IEEE

Supercomputing and a Distinction Award from the Audio Engineering Society. The research I supervised on the Autour project earned the Hochhausen Research Award from the Canadian National Institute for the Blind and an Impact Award from the Canadian Internet Registry Association, and my Real-Time Emergency Response project won the Gold Prize (brainstorm round) of the Mozilla Ignite Challenge.

10. I have worked with IBM at the Haifa Research Center, Israel, and the Watson Research Center in Yorktown Heights, New York, the Sony Computer Science Laboratory in Tokyo, Japan, and was a visiting professor at Bang & Olufsen, Denmark, where I conducted research on telepresence technologies as part of the World Opera Project. I led the theme of Enabling Technologies for a Networks of Centres of Excellence on Graphics, Animation, and New Media (GRAND) and I am an associate editor of the Journal of the AES.

11. I have carried out significant research involving network communication protocols, including wireless communication employing IEEE 802.11 (WiFi) and IEEE 802.15 (Bluetooth). My experience in these areas includes development of the Adaptive File Distribution Protocol (AFDP, 1995), analysis of the tradeoffs between bandwidth, power demands, and latency for audio streaming over WiFi, Bluetooth, and ultra-wideband protocols (2007), and assessment of the performance and scalability of wireless audio streaming for

applications requiring latency-optimized multimedia streaming (2008). I have led all aspects of development and experimentation in the Autour project (2009-2016), for which Bluetooth is typically used as a communication layer for audio between the user's smartphone and a wireless headset, or, experimentally, to transmit user input acquired from a wireless game controller. I am currently leading a research project (MIMIC), which communicates sensor data between two coupled smartwatches using Bluetooth for local communication between the smartwatches and their peered smartphones, and the public Internet between the smartphones. I am also leading a project that uses both Bluetooth and WiFi communication between smartphones, a GPU-based physics engine, and a microelectronics architecture that renders vibrotactile effects on mobile footwear.

12. My experience in academic and practical situations as well as my hands on experience with wireless communication systems such as Bluetooth systems provides me with an appreciation of the technology involved with U.S. Patent No. 10,491,982 ("the '982 patent" or APPLE-1001).

III. BACKGROUND

13. I have reviewed the '982 patent and relevant excerpts of the prosecution history of the '982 patent ("the Prosecution History" or APPLE-1002). The '982 patent claims priority through a string of applications that includes U.S. provisional application 61/123,265 filed on April 7, 2008. See APPLE-1001, Face.

understood by a POSITA. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. I also understand that the words of the claims should be interpreted as they would have been interpreted by a POSITA at the time of the invention was made (not today). Because I do not know at what date the invention as claimed was made, if ever, I have used the Critical Date of the '982 patent as the point in time for claim interpretation purposes. My opinion does not change if the invention date is earlier.

D. Person of Ordinary Skill in the Art

30. Based upon my experience in this area and taking into account the above references, a person of ordinary skill in the art at the time of the '982 patent's Critical Date ("POSITA") would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks. Superior education could compensate for a deficiency in work experience, and vice-versa.

31. I base this characterization of a POSITA in view of my professional, academic, and personal experiences, including my knowledge of colleagues and others at the time of the invention of the '982 patent on or shortly before the

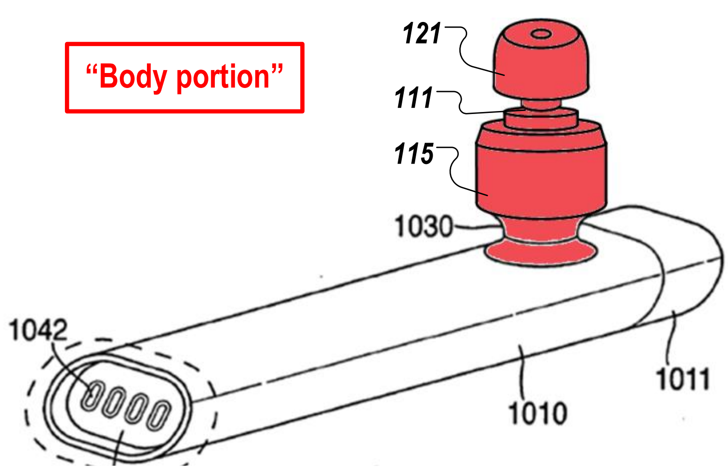
45. Rosener describes implementation details for transmitting an independent data stream from the external audio device to each of the earphones (e.g., FIGs. 6-14) and for enabling stereo play, despite transmission of such independent streams to electrically and mechanically independent earphones, by compensating for any differential latencies that may arise between the two data streams (e.g., ¶¶[0039-0042]). Rosener, however, is silent as to the implementation details of arranging Rosener's electrical components within the compact form factor of each of the earphones 502, 504, and contains only a limited disclosure of the details of the earphones' form factor. That is, beyond Rosener's FIG. 5 that shows an overview of a small earphone's form factor, and beyond its disclosure of including general headset components (e.g., transceiver, speaker, battery) in each of those earphones, Rosener provides little detail regarding how to arrange those components within the small form of each earphone 502, 504. To implement such earphones, therefore, a POSITA would have sought disclosure of small form factors for use in earphones and techniques for arranging electrical components within those small earphones.

46. As explained in Section VI.A.2, Hankey discloses such small earpieces and techniques needed to assemble electrical components within a small and compact housing of the earpieces. Hankey discloses a compact earpiece capable of communicating with external audio devices wirelessly. Hankey

considers the size and weight of prior art headsets as a "key issue" that causes an uncomfortable fit of the headsets on a user's ear. APPLE-1005, ¶[0011]; APPLE-1008, ¶[0003]. To resolve this issue, Hankey provides techniques to package electronics within a "a small compact unit" to alleviate the size and shape hassles of conventional headsets. APPLE-1005, ¶¶[0092-98]. Hankey's techniques include dividing the earpiece's electrical assemblies into small groups of electrical components (e.g., by mounting the components on small circuit boards) and connecting those small groups to each other by flexible connectors such as flexible circuit boards. *Id.* A POSITA would have been motivated to use Hankey's techniques to arrange the components of each of Rosener's earphones 502, 504 to fit within the small, compact form factor shown in Rosener's FIG. 5.

47. Being aware of Hankey's techniques of implementing a small compact earpiece, a POSITA would have understood that one way to implement each of Rosener's earphones 502, 504 would be to divide the corresponding electronic assemblies of the earphone into two portions, and electrically couple the components in each of the portions by a flexible electrical connector. *See id.*, ¶¶[0094], [0096]. One portion could be a top part of the earphone and the other portion could be "a longitudinal member" extending away from the top portion. *Id.* The top part includes the earbud portion of the earphone, and contains electronic components such as a processor and an acoustic transducer of the

97. As noted above in Section VI.B.2, to the extent a POSITA would seek additional implementation details for a canalphone, the POSITA could turn to the teachings of Dyer. . In doing so, a POSITA would arrive at a combined Rosener-Hankey-Dyer canalphone, such as, for example, the canalphone shown in the following figure, which includes a ***body portion*** containing canalphone elements, including the acoustic components, of Dyer's canalphone.



Rosener-Hankey-Dyer canalphone.

98. The contemplated body portion of each of earphones 502, 504 is highlighted in Rosener's annotated figure below and corresponds to the portion of the housing that contacts a user's ear and is inserted into an ear of user 500 when worn.

Biographical

Personal Data

Nationality	Canadian
Languages	English, French and Hebrew
Address	Department of Electrical and Computer Engineering, McGill University 3480 University Street, Montreal, QC, H3A 0E9, Canada
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email	jer@cim.mcgill.ca

Degrees Awarded

Ph.D.	Electrical and Computer Engineering, University of Toronto, 1996. Thesis: "Reactive Environments and Augmented Media Spaces." (Nominated for NSERC Doctoral Dissertation Award) Advisors: Prof. K.C. Smith and Prof. W. Buxton
M.Sc.	Computer Science, University of Toronto, 1992. Thesis: "Neural Network Operated Vision-Guided Mobile Robot Arm for Docking and Reaching." Advisor: Prof. E. Milios.
B.A.Sc.	Electrical Engineering, Computer Engineering Option, University of British Columbia, 1990 (Honours)

Awards and Distinctions

2019	San Diego Opera, Opera Hack award, Hamsafar! ($10,000, with 5 co-awardees)
2015	Gerald W. Farnell Teaching Scholar, Faculty of Engineering ($12,500)
2014	US Ignite Best App in Education, Augmented Reality for Improved Training of First Responders
2013	Canadian National Institute for the Blind, Hochhausen Access Technology Research Award ($10,000)
2012	Mozilla Foundation and NSF Gold Prize in the Mozilla Ignite Challenge (out of 305 submissions in the Brainstorming Round) ($5,000) for Real-Time Emergency Response
2012	Canadian Internet Registry Association .CA Impact Award (Applications category) for In-Situ Audio Services Project ($5,000)
2009, 2010	Nominee, NSERC Brockhouse Canada Prize
2005	ACM/IEEE Supercomputing, Most Innovative Use of New Technology for Wide Screen Window on the World: Life Size HD Videoconferencing
2001	Audio Engineering Society Citation Award for pioneering the technology enabling collaborative multichannel performance over the broadband internet

Work Experience

Career Highlights

Autour (with HQP J. Blum, D. El-Shimy, A. Olmos, S. Panëels, F. Grond, and M. Bouchard) is an "eyes-free" app for the blind, which provides a rich, spatialized audio representation of one's environment [J19, C55, C46, C43]. The project further motivated a rigorous analysis of smartphone sensor reliability, resulting in what was the first comprehensive examination of practical limits on smartphone sensors, including the problems of gyro drift [C46].

Mobile Treatment Device for Amblyopia (with HQP L. To and J. Blum, and in collaboration with ophthalmologist R. Hess) is a patented prototype Mobile Treatment Device for Amblyopia [P7] ("lazy eye"). Initial trials [J18], based on the popular Tetris game, provided highly promising early results [J25, J21], not only restoring the use of both eyes in a majority of patients but even resulting in binocular (3D) depth perception in some. Most significantly, the treatment has been found to work successfully on adult populations, whereas the prevailing wisdom had been that treatment was only possible on children. The technology has now been acquired by Novartis, who are commercializing the system.

Real-Time Emergency Response (rtER) (with HQP S. Smith, J. Blum, A. Eichhorn, J. Anlauff, S. Beniak, N. Jain, and S. Salenikovich) provides an envisionment of the future of next-generation 911 (NG-911) technologies, supporting enhanced situational awareness for first responders through the use of citizen-supplied smartphone video streams and other relevant data [J11]. Our work was recognized by the *Gold Prize* from the Mozilla Ignite Fund, featured on the web site of the White House Office of Science and Technology, and prompted the launch of a funding program by the U.S. Department of Justice.

Natural Interactive Walking (with HQP Y. Visell, A. Law, G. Millet, M. Otis, and S. Panëels) investigated multimodal interaction with virtual ground surfaces, resulting in important findings of tactile discrimination ability [J20] and the role of vibrotactile stimulation in perception of compliance [J26]. Our "Ecotile" prototype (patent [P4]) was showcased at numerous venues including SIGGRAPH, and led to related research involving limb modeling [C57, C41, C35], foot-water interaction [J13], and variable-friction walking interfaces [C51, C42, J4].

Ultra-Videoconferencing is our low-latency, high-fidelity network transport, used for distance music teaching with Maestro Pinchas Zuckerman, cross-continental jazz jams, and remote sign language interpretation. The Globe and Mail described Cooperstock's 2001 demonstration as "a watershed event for the elite club of the world's computer network engineers." Ultra-Videoconferencing garnered my research group a prestigious Citation Award from the Audio Engineering Society and the Award for Most Innovative Use of New Technology from ACM/IEEE Supercomputing (2005). This research directly constituted the basis for subsequent funding of $2.2M from Valorisation Recherche Quebec and over $4M from Canarie, and influenced the designs of similar telepresence videoconferencing systems from Cisco, HP, and Polycom. Our follow-up work on **Open Orchestra** (with HQP N. Bouillot, A. Olmos, T. Knight, M. Tomiyoshi), resulted in an immersive simulator for orchestral training, used by professional and semi-professional musicians [J17].

Academic Experience

January 2018 – present	**McGill University, Montreal, QC** Full Professor, Electrical and Computer Engineering. Director, Shared Reality Lab; supervised over 50 graduate students, post-doctoral fellows, and research associates
September 2018 – June 2019	**Technion–Israel Institute of Technology, Haifa, Israel** Visiting Professor, Industrial Engineering and Management
September 2018 – June 2019	**IDC, Herzliya, Israel** Visiting Professor, Department of Computer Science
May 2003 – Dec. 2017	**McGill University, Montreal, QC** Associate Professor, Electrical and Computer Engineering
Aug. 2011 – Jul. 2012	**University of Auckland, New Zealand** Invited Professor, Department of Computer Science
May–June 2009	**Bang & Olufsen, Denmark** Visiting Professor, World Opera Project
Jan 2009 – present	**Bielefeld University, Germany** Virtual Member, Center of Excellence Cognitive Interaction Technology (CITEC)
Feb 2008	**Arizona State University** Visiting Scholar, School of Arts, Media and Engineering
Sep. 2004 – Aug. 2005	**Université de Paris VI, Paris France** Invited Professor, Laboratoire des Instruments et Systemes d'Ile-de-France
Apr. 2000 – present	**McGill University, Montreal, QC** Associate Member, Faculty of Music, Department of Theory.
Nov. 1997 – May 2003	**McGill University, Montreal, QC** Assistant Professor, Electrical and Computer Engineering.

Industrial and Consulting Experience

Sep. 2019 – present	**RedPill Canada VR, Montreal** Director and Advisor
Apr. – Jun. 2019	**(Confidential project as consulting expert)** Providing expert report on topics concerning Human-Computer Interaction.
Aug. – Nov. 2014	**Menya Solutions and DRDC-Valcartier** Providing expert advice related to human-computer interfaces, visualization, and collaboration.
August 2012	**Tamaggo Inc.** Provide guidance and advice on digital imagery
May 2012	**York University** Review draft application to Canada Excellence Research Chairs program
May 2002 – Nov. 2003	**Solicitor General of Canada** Media streaming configuration and user interface design.
May 2001	**National Research Council** Instructor of short course in Soft Computing, Institut des Materiaux Industriels.
Jan. – Sep. 1999	**Audio Engineering Society** Technical leader of demonstration of multichannel and multimedia audio distribution
Jan. – Aug. 1999	**Ontario Science Center** Scientific Director of Timescape Millenium Exhibit
July 1998	**Nortel** Instructor of short course in videoconferencing systems for the Nortel International SL-1 User's Association (ILUA), Long Beach
Sep. 1996 – Oct. 1997	**Sony Computer Science Laboratory** Visiting Researcher, Sony Computer Science Laboratory, Tokyo, Japan. Developed speech-interface controlled VCR with visual tape database functionality. Wrote two patent applications, one filed.
June – Aug. 1990	**Fibronics Research** Visiting Researcher, Fibronics Advanced Research Center, Haifa, Israel. Developed and tested an FDDI-to-token ring bridge.
May – Aug. 1989	**IBM T.J. Watson Research Center** Research Intern, IBM T.J. Watson Research Center, Yorktown Heights, NY. Improved implementation of a VLIW architecture simulator.

Litigation and Expert Witness Experience

Parties I represented are marked by an asterisk.

Oct. 2020 – ongoing **Koss Corporation v. Apple***
United States Distrcit Court, Western District of Texas, Case No. 6:20-cv-00665 and *Inter Partes* Review of U.S. Patent Nos. 10,206,025, 10,469,934, 10,506,325, 10,491,982, and 10,298,451 in the United States Patent and Trademark Office.

Oct. 2020 – ongoing **ByteDance* and TikTok* v. Triller**
Inter Partes Review of U.S. Patent No. 9,691,429 in the United States Patent and Trademark Office.

Sep. 2020 – ongoing **Content Square v. Quantum Metric* and Decibel Insight***
United States District Court, Massachusetts District Court, Case No. 1-20-cv-11184 and Delaware District Court, Case No. 20-cv-00832. Involved in invalidity arguments and petitions for *Inter Partes* Review.

Sep. 2020 – ongoing **Wiesel v. Apple***
United States District Court, Eastern District of New York, Case No. 1:19-cv-7261. Involved in source code review of products related to the Apple Watch.

Aug. 2020 – Oct. 2020 **Finish Time* v. Garmin**
United States District Court, District of Maine, Case No. 2:20-cv-00184. Involved in review of infringement arguments, discovery, related to fitness applications.

Dec. 2019 – ongoing **Pinn v. Apple***
United States District Court, Central District of California, Case No. 8:19-cv1805, *Inter Partes* Review IPR2020-00999, Post Grant Review PGR2020-00066 and PGR2020-00073. Involved in preparation of expert witness declarations, code analysis involving multiple products related to earbud and charging units. Deposition testimony on expert reports.

Oct. 2019 **Apple* v. Qualcomm**
Inter Partes Review, Case no. IPR2018-01279. Deposition testimony on expert witness declaration related to multimedia messaging.

May 2018 – May 2019 **Samsung* v. Immersion**
Civil Action No. 2:2018-cv-00055 in the Eastern District of Texas and *Inter Partes* Review, case no. IPR2018-01499. Consulted on technical details and involved in preparation of two expert witness declarations related to haptic feedback effects and force feedback in a multimodal system.

May 2016 – Nov. 2017 **Cooperstock* v. Air Canada**
Petitioner before the Canadian Transportation Agency. Brought successful complaint against Air Canada for the airline's making false or misleading statements to the public, Decision No. 105-C-A-2017 (otc-cta.gc.ca/eng/ruling/105-c-a-2017)

Jan. – May 2014	**St. Lewis v. Rancourt*** Provided expert report on web server location, Ontario Superior Court File No. 11-51657
Mar. – Sep. 2013	**Cooperstock* v. United Airlines** Brought and argued successful appeal regarding anti-SLAPP legislation before the Quebec Court of Appeal, Decision 2013 QCCA 1670 (goo.gl/pgz301). Argued appeal in person (September 26, 2013)
Nov. 2012 – Aug. 2017	**United Airlines v. Cooperstock*** Pro se litigant, Federal Court File No. T-2084-12. Deposition as litigant (August 2013) and testified at trial (December 2016).
Nov. 2012 – Jan. 2017	**United Airlines v. Cooperstock*** Pro se litigant, Quebec Superior Court File No. 500-17-074743-124. Deposition as litigant (October 2014) and testified at trial (April 2016).
Sep. 2012	**Lukács* v. Air Canada** Provided expert report on database query and execution times, Canadian Transportation Agency File No. M4120-3/11-06673, Decision No. 204-C-A-2013
May 2007 – Jan. 2008	**Market Maker c. Brim Solutions*** Provided expert witness report and in-court testimony (October 2007) on software-related intellectual property case. Quebec Superior Court File No. 500-17-036750-076.
Feb. – Oct. 2004	**Crawford Adjusters Canada** Provided analysis of artifacts in high definition video
Jul. 2002 – May 2016	**Court of Quebec, Small Claims Division** Brought 14 consumer rights complaints before the Court, 11 of which were successful

US 20080076489A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2008/0076489 A1**
Rosener et al. (43) **Pub. Date: Mar. 27, 2008**

(54) **PHYSICALLY AND ELECTRICALLY-SEPARATED, DATA-SYNCHRONIZED DATA SINKS FOR WIRELESS SYSTEMS**

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345 ENCINAL STREET, P.O. BOX 635
SANTA CRUZ, CA 95060-0635

(73) Assignee: **PLANTRONICS, INC.**

(21) Appl. No.: **11/500,571**

(22) Filed: **Aug. 7, 2006**

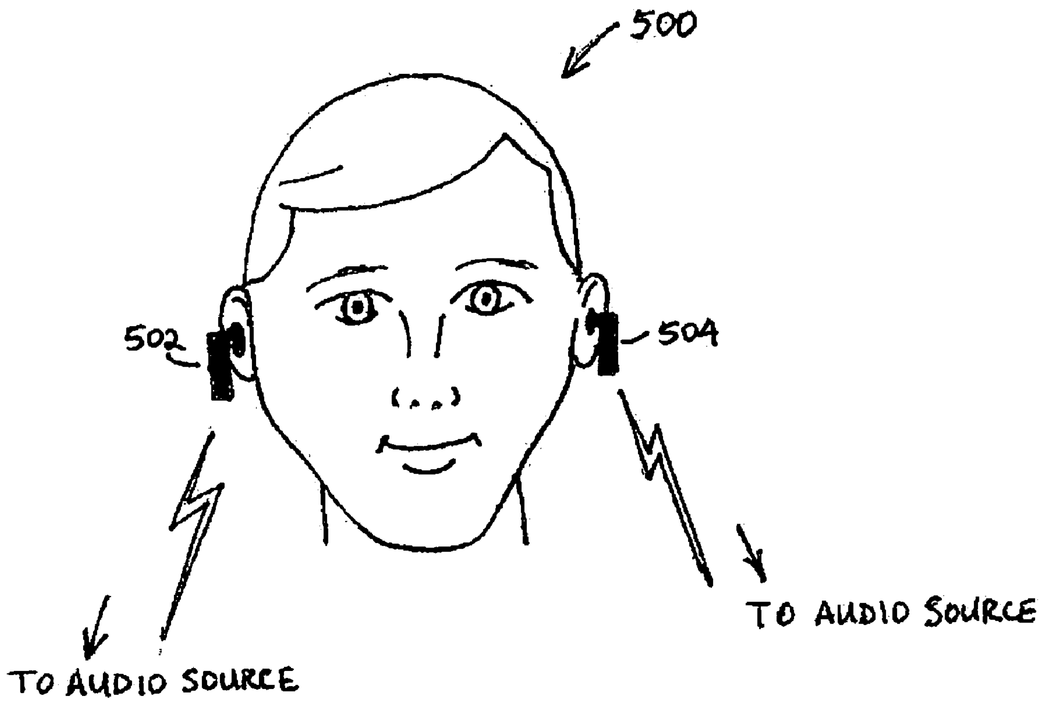
Publication Classification

(51) **Int. Cl.**
H04M 1/00 (2006.01)

(52) **U.S. Cl.** **455/575.2**

(57) **ABSTRACT**

Wireless systems having a plurality of physically and electrically-separated data sinks. An exemplary wireless system includes first and second data sinks having no physical or electrical connection therebetween. The first and second data sinks each include a wireless communication device, e.g., a radio frequency (RF) receiver or transceiver configured to receive data signals over one or more single-access wireless links or over a multi-access wireless link. The first and second data sinks in exemplary embodiments may comprise audio data sinks, e.g., stereo speakers, left-ear and right-ear earphones (e.g., earbuds or canalphones), left-ear and right-ear circum-aural over-the-ear headphones, etc. At least one of the first and second data sinks may also be coupled to a wireless transmitter and accompanying data source (e.g., a microphone or sensor), so as to provide, for example, two-way communications between a user and an external data device (e.g., a cellular telephone).



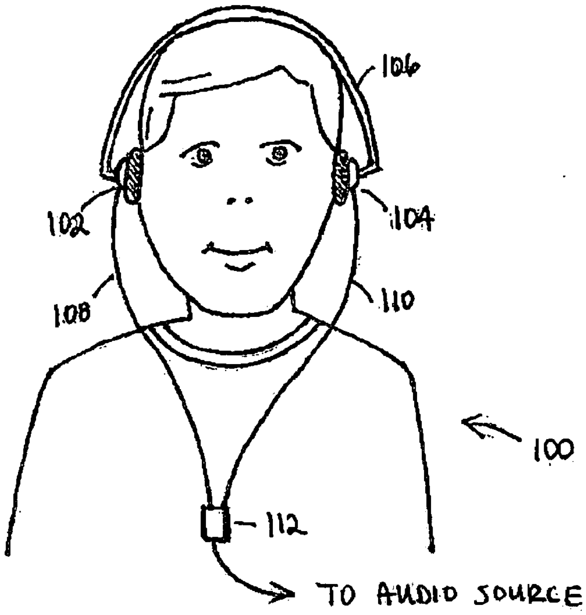


FIGURE 1A
(PRIOR ART)

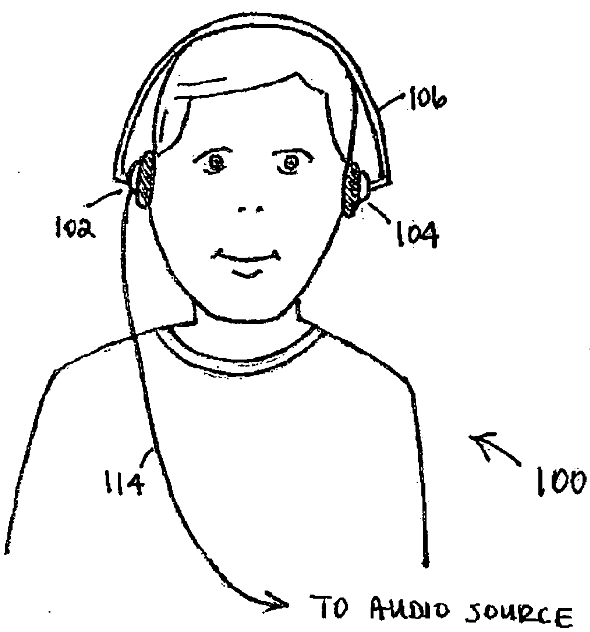


FIGURE 1B
(PRIOR ART)

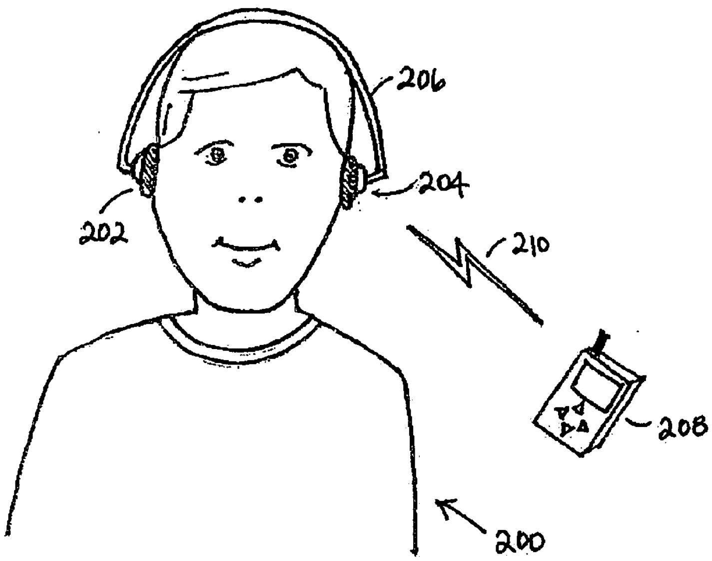


FIGURE 2
(PRIOR ART)

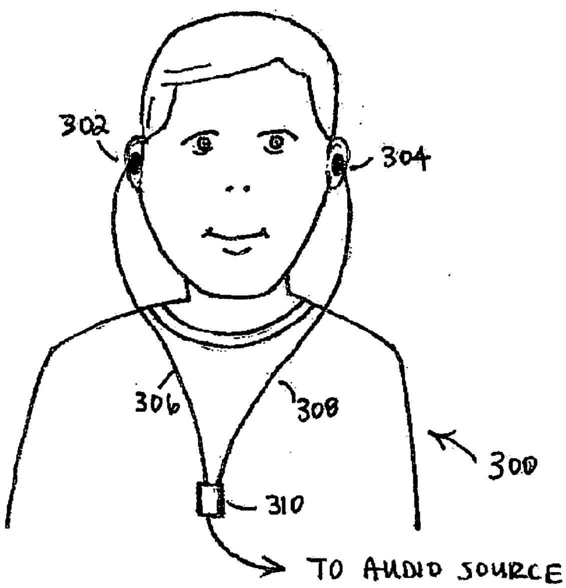


FIGURE 3
(PRIOR ART)

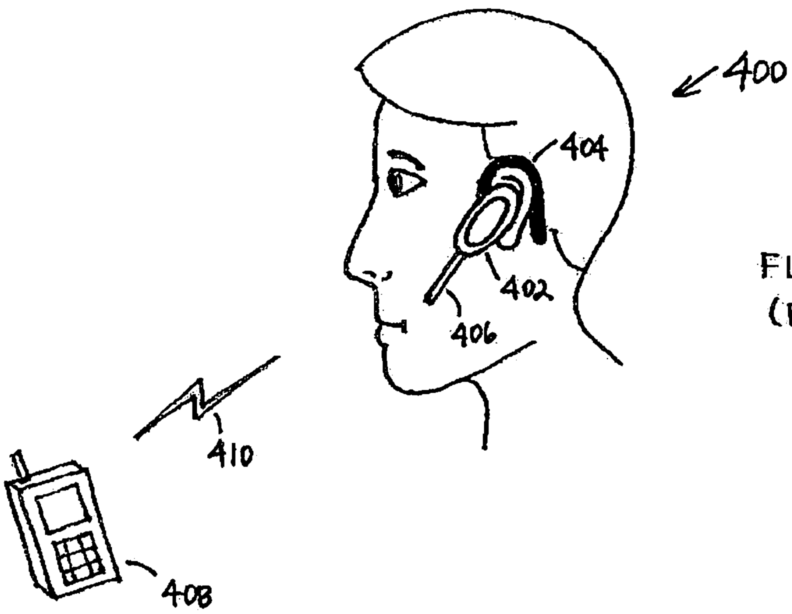


FIGURE 4
(PRIOR ART)

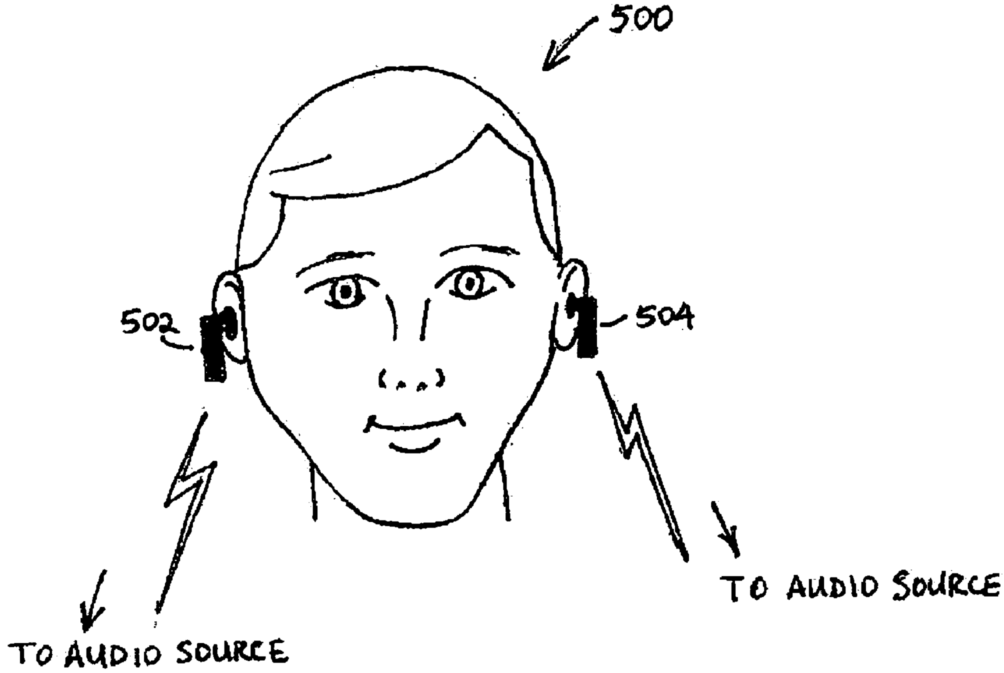


FIGURE 5

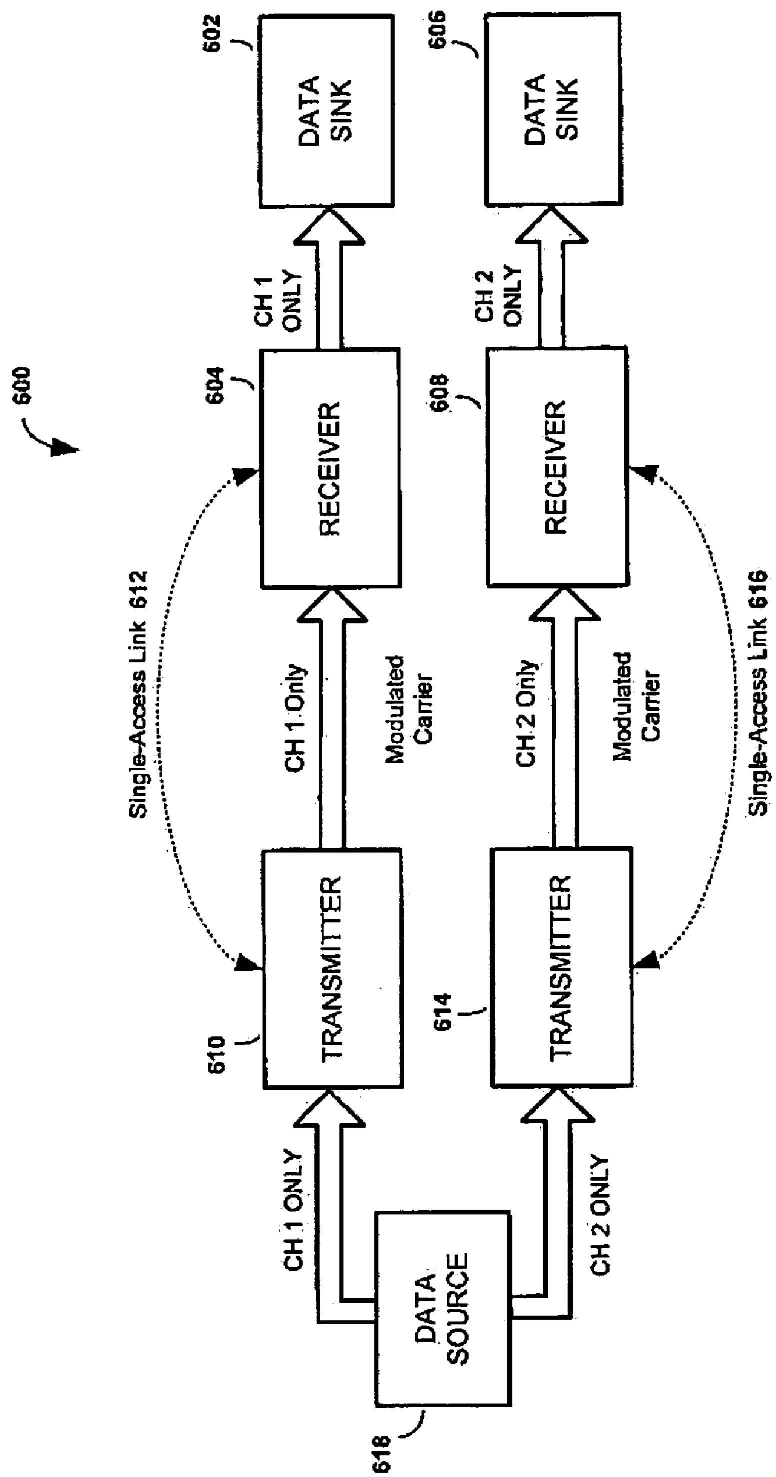

600
602
DATA SINK
606
DATA SINK
CH 1 ONLY
CH 2 ONLY
604
RECEIVER
608
RECEIVER
Single-Access Link 612
CH 1 Only
Modulated Carrier
CH 2 Only
Modulated Carrier
Single-Access Link 616
610
TRANSMITTER
614
TRANSMITTER
CH 1 ONLY
DATA SOURCE
CH 2 ONLY
618

FIGURE 6

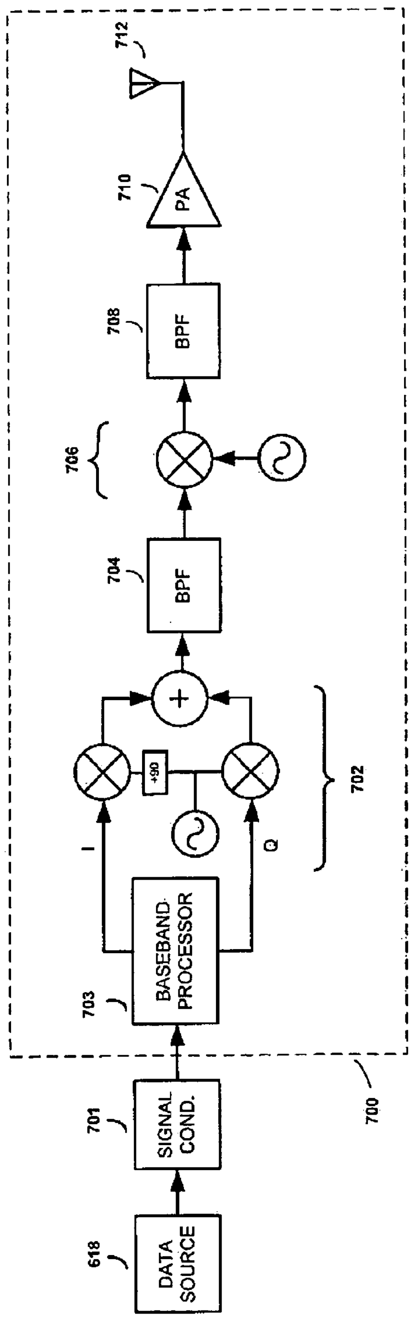


FIGURE 7A

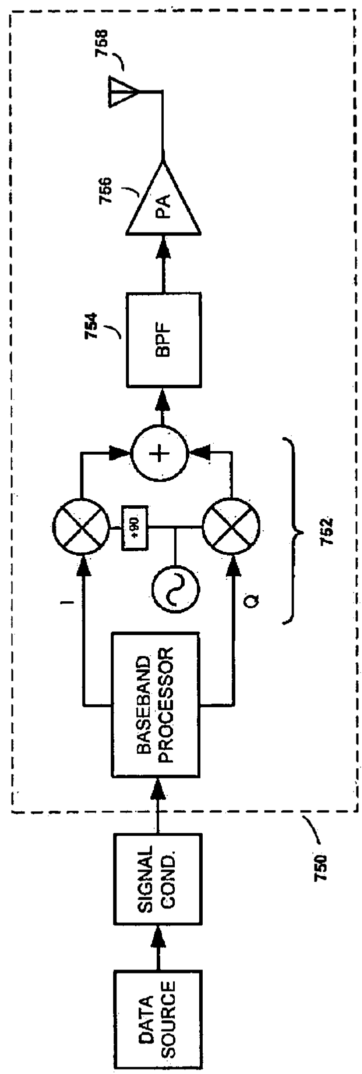


FIGURE 7B

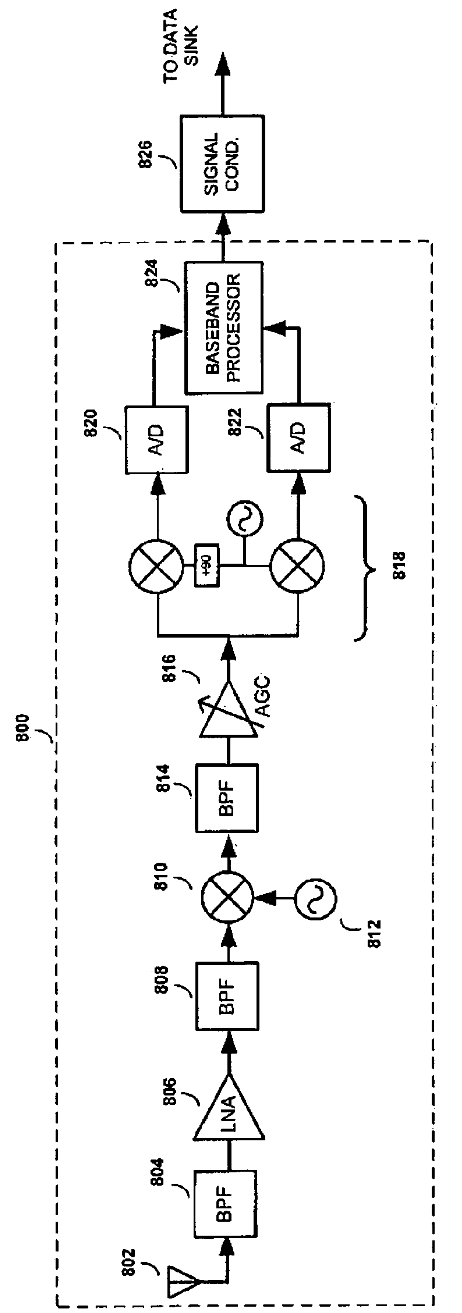


FIGURE 8A

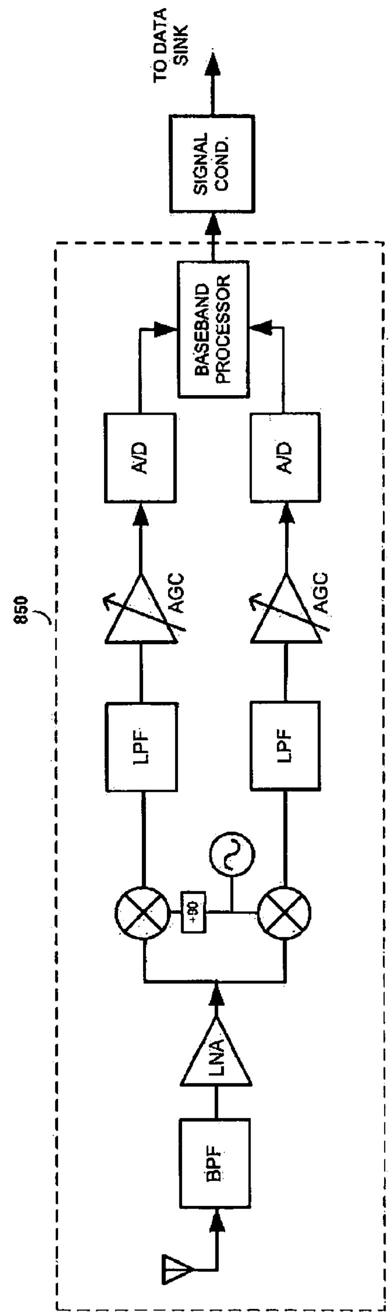


FIGURE 8B

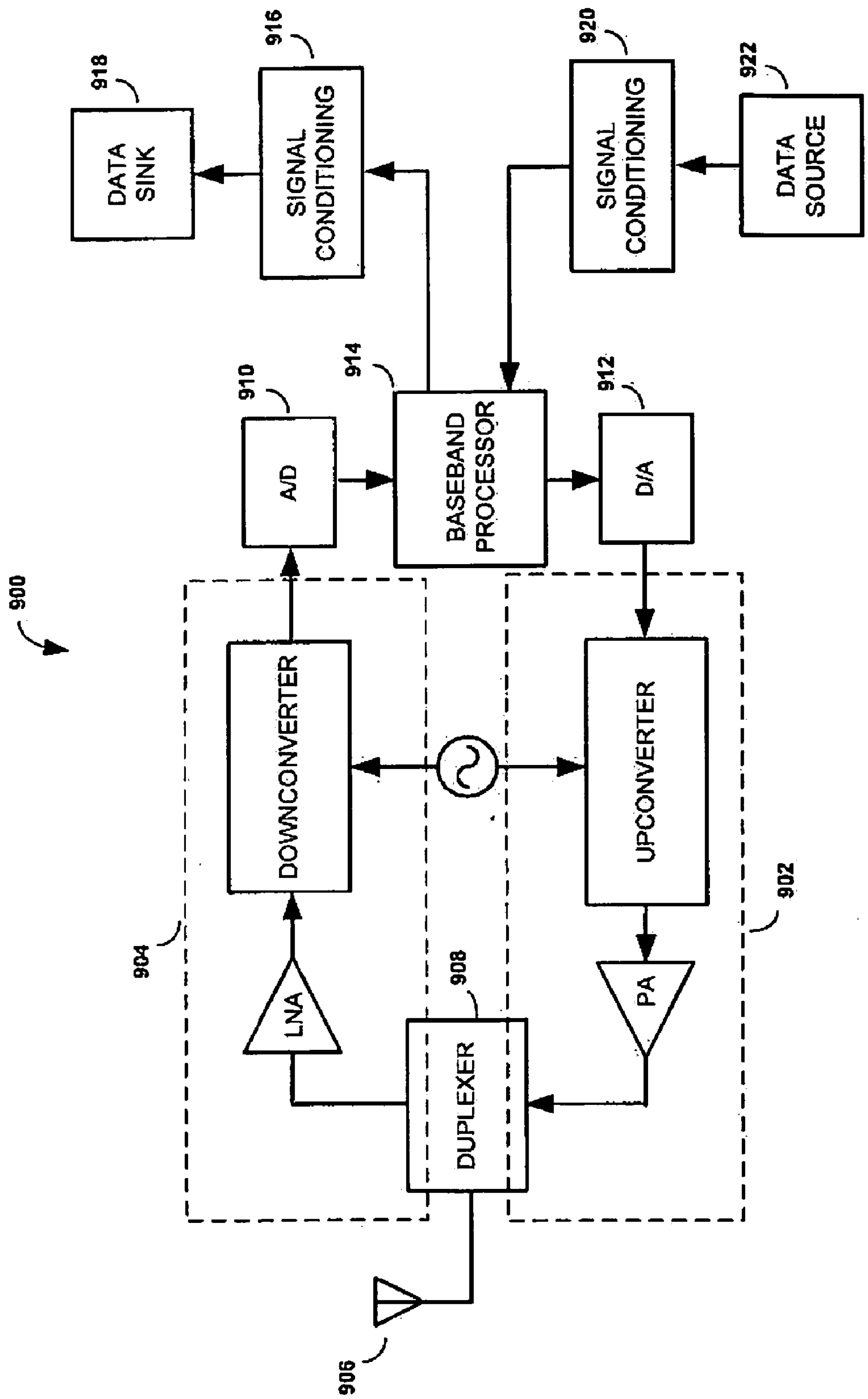

900
918
DATA SINK
916
SIGNAL CONDITIONING
920
SIGNAL CONDITIONING
922
DATA SOURCE
910
A/D
914
BASEBAND PROCESSOR
912
D/A
DOWNCONVERTER
UPCONVERTER
904
902
LNA
PA
908
DUPLEXER
906

FIGURE 9

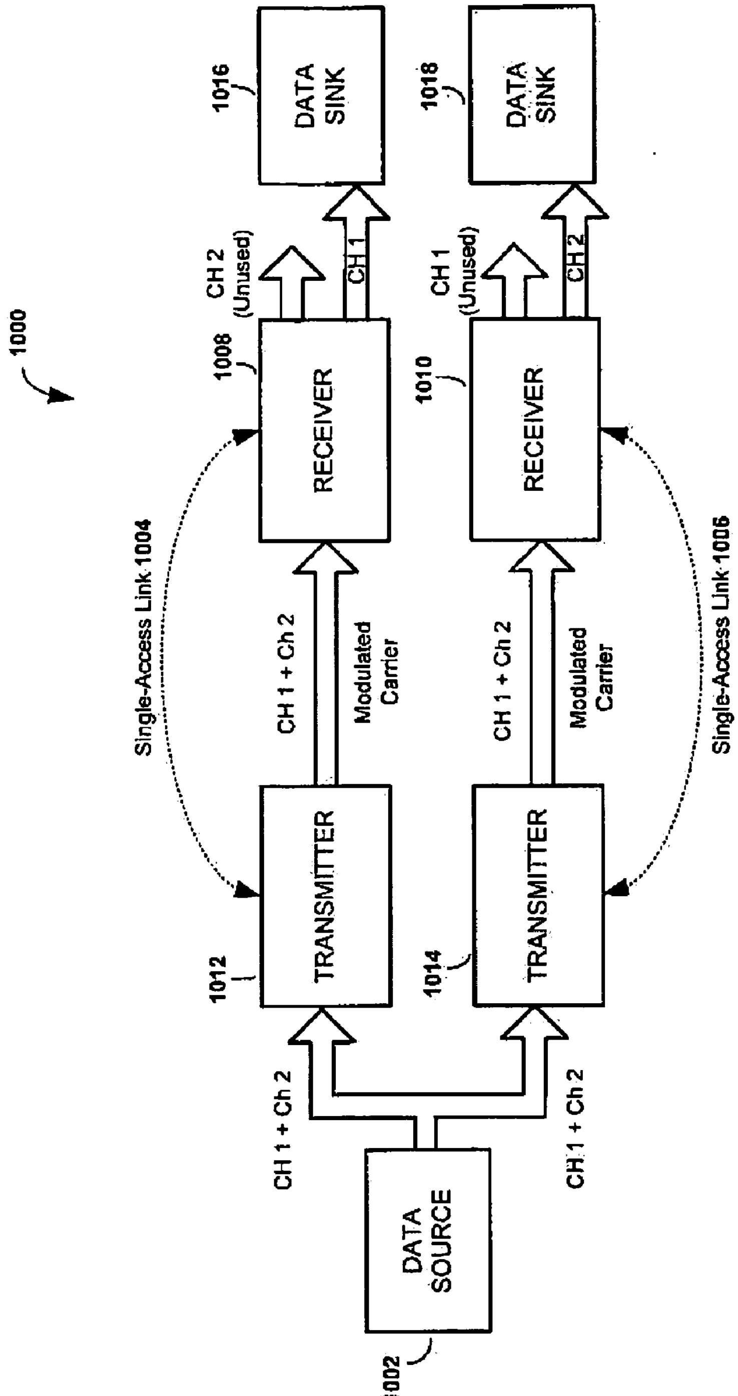

1000
DATA SOURCE
1002
CH 1 + Ch 2
CH 1 + Ch 2
TRANSMITTER
1012
TRANSMITTER
1014
CH 1 + Ch 2
Modulated Carrier
CH 1 + Ch 2
Modulated Carrier
Single-Access Link 1004
Single-Access Link 1006
RECEIVER
1008
RECEIVER
1010
CH 2 (Unused)
CH 1
CH 1 (Unused)
CH 2
DATA SINK
1016
DATA SINK
1018

FIGURE 10

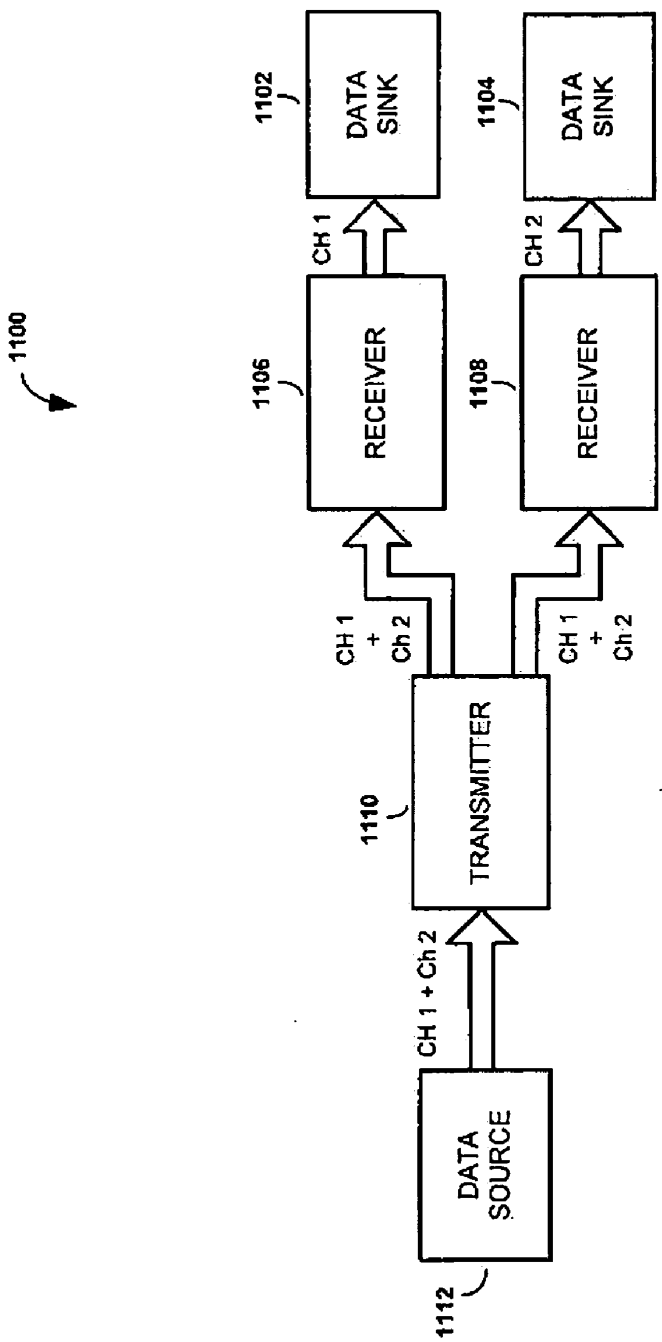
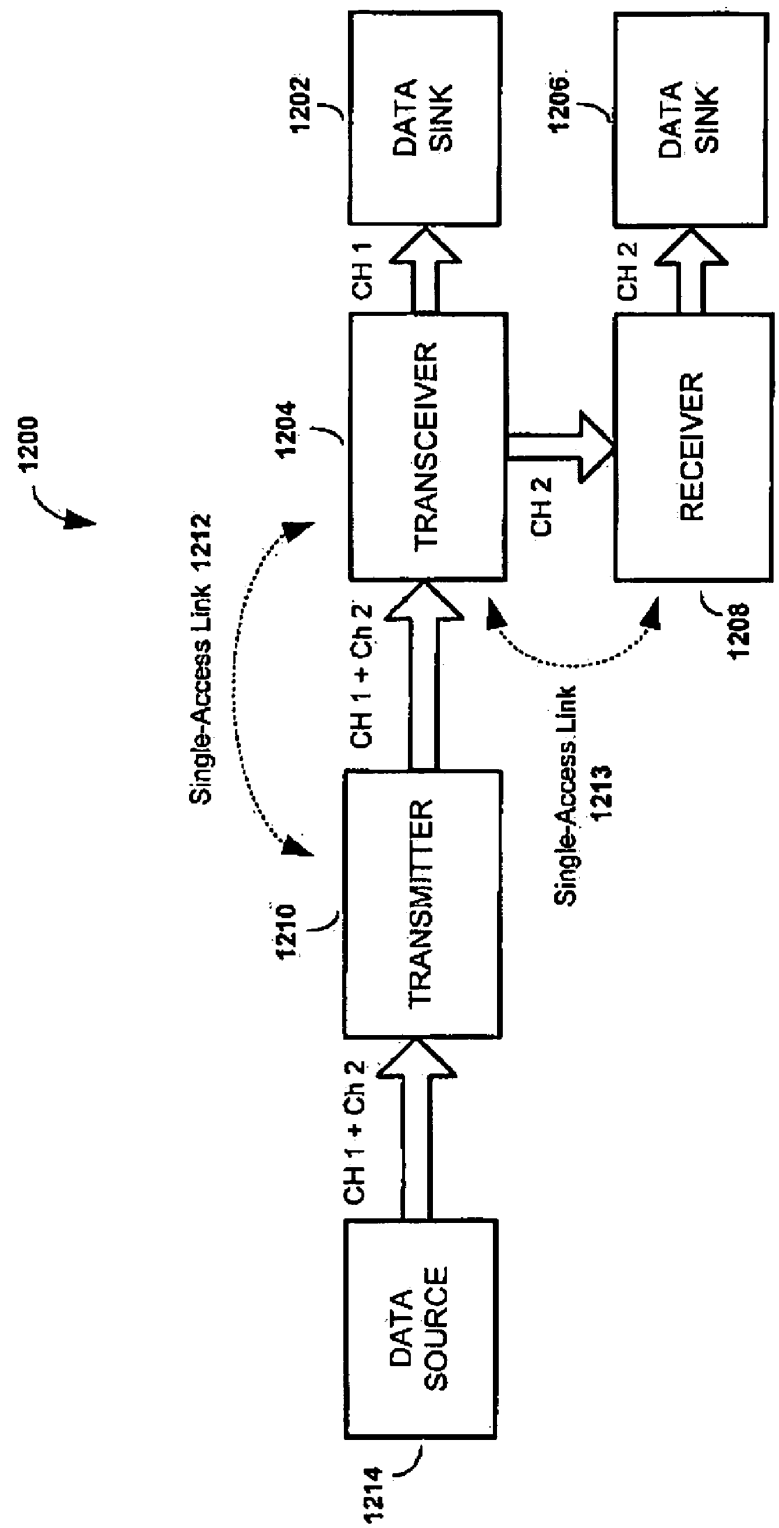

1100
1102
DATA SINK
1104
DATA SINK
CH 1
CH 2
1106
RECEIVER
1108
RECEIVER
CH 1 + Ch 2
CH 1 + Ch 2
1110
TRANSMITTER
CH 1 + Ch 2
1112
DATA SOURCE

FIGURE 11



1200
1202
DATA SINK
1206
DATA SINK
CH 1
CH 2
1204
TRANSCEIVER
CH 2
RECEIVER
1208
Single-Access Link 1212
CH 1 + Ch 2
Single-Access Link 1213
1210
TRANSMITTER
CH 1 + Ch 2
DATA SOURCE
1214

FIGURE 12

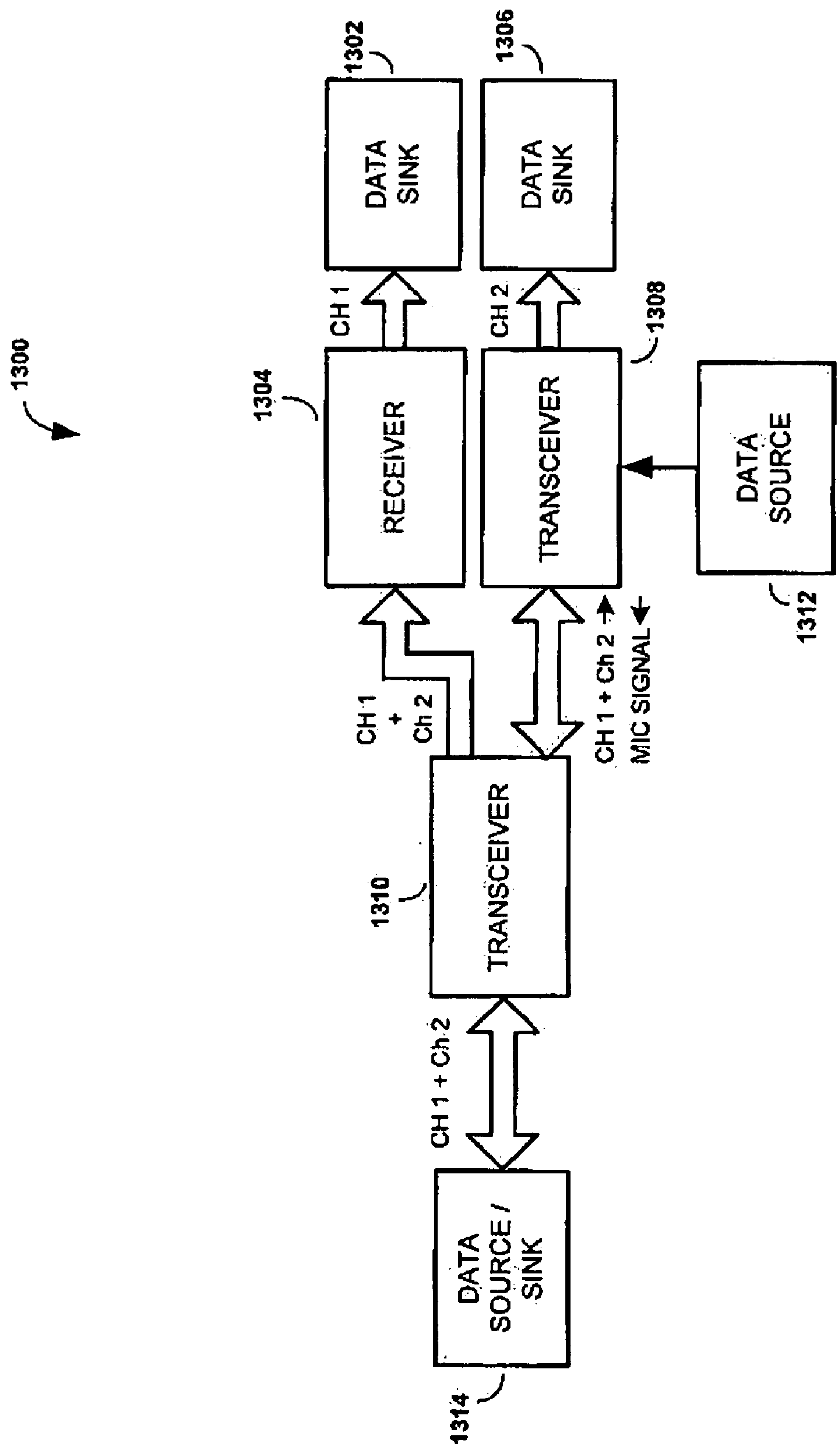

1300
1302
DATA SINK
1306
DATA SINK
CH 1
CH 2
1308
1304
RECEIVER
TRANSCEIVER
DATA SOURCE
1312
CH 1 + Ch 2
CH 1 + Ch 2
MIC SIGNAL
1310
TRANSCEIVER
CH 1 + Ch 2
DATA SOURCE / SINK
1314

FIGURE 13

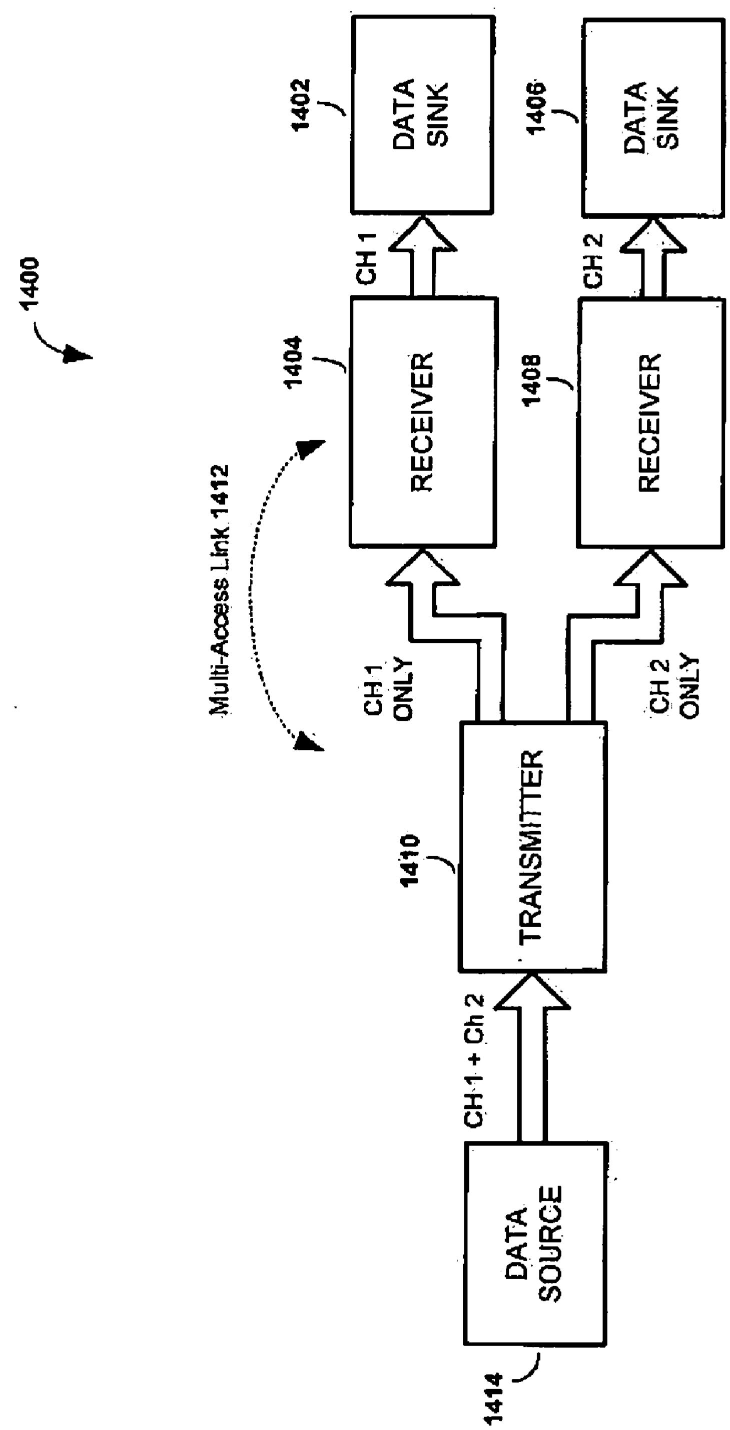

1400
Multi-Access Link 1412
1402
DATA SINK
CH 1
1404
RECEIVER
1406
DATA SINK
CH 2
1408
RECEIVER
CH 1 ONLY
CH 2 ONLY
1410
TRANSMITTER
CH 1 + Ch 2
DATA SOURCE
1414

FIGURE 14

PHYSICALLY AND ELECTRICALLY-SEPARATED, DATA-SYNCHRONIZED DATA SINKS FOR WIRELESS SYSTEMS

FIELD OF THE INVENTION

[0001] The present invention relates to wireless systems. More particularly, the present invention relates to wireless communication between a data source and two or more and physically and electrically-separated wireless data sinks such as, for example, wireless earphones.

BACKGROUND OF THE INVENTION

[0002] Headphones have come into widespread use ever since they were invented in the late 1930s. Today, headphones are used in numerous industrial settings, for listening to music and radio broadcasts, and for receiving voice communications from mobile telephones. A conventional pair of headphones comprises a pair of sound transducers (i.e., speakers), which are configured to receive electrical signals from an audio source (e.g., compact disk (CD) player, digital audio player (MP3 player), cellular telephone, personal digital assistant (PDA), or personal computer) and provide sound to a user's ears.

[0003] FIGS. **1**A and **1**B are illustrations of a user **100** wearing two different types of early-model headsets The headset in FIG. **1**A comprises a pair of headphones **102**, **104**, a headband **106** and a pair of electrical cables **108**, **110**, which connect the headphones **102**, **104** to an external audio source. The headband **106** is worn over the top of the user's **100** head, and physically connects the pair of headphones **102**, **104**. A cable clip **112** may be used to secure the electrical cables **108**, **110** so that they do not interfere with the movement of the user **100** and to prevent tangling of the electrical cables **108**, **110**. The headset in FIG. **1**B is similar to the headset in FIG. **1**A, except that only a single electrical cable **114** is connected between one of the headphones **102**, **104** and the audio source. Because cabling is provided only to a single headphone **102**, electrical wiring is routed through the headband **106** to electrically connect the headphones **102**, **104**. The headsets in FIGS. **1**A and **1**B are often referred to in the art as "binaural" headsets since they each comprise a headset having a pair of headphones **102**, **104** for each of the user's **100** ears.

[0004] Recent advances in wireless technology have allowed the design and manufacture of wireless headsets. For example, the recent introduction of the Bluetooth industrial specification (also known as the IEEE 802.15.1 standard) allows a user to establish a short range wireless personal area network (PAN) in which various electronic devices (e.g., cell phones, PDA's, MP3 players, personal computers, printers, etc.) can communicate with each other over wireless links. Because the PAN is a radio communication system using low gain antennas, the Bluetooth enabled devices do not have to be in line of sight of each other. Furthermore, because the PAN is completely wireless, the clutter and obstruction of electrical cables can be avoided.

[0005] FIG. **2** is an illustration of a user **200** wearing a binaural Bluetooth enabled headset. Similar to the wired headsets in FIGS. **1**A and **1**B, the Bluetooth enabled headset in FIG. **2** comprises a pair of headphones **202**, **204** and a headband **206**, which physically connects the pair of headphones and provides support for positioning the headset over the user's **200** head. Electrical wiring within the headband **206** electrically connects the pair of headphones **202**, **204**. Rather than using electrical cabling between the headphones **202**, **204** and the external audio source, as is done in the conventional wired headsets in FIGS. **1**A and **1**B, one of the headphones **202**, **204** of the Bluetooth enabled headset includes a Bluetooth transceiver that wirelessly communicates with a Bluetooth enabled external audio source **208** over a wireless link **210**.

[0006] The binaural wireless headset in FIG. **2** does afford the benefits of wireless operation. However, similar to the traditional wired headsets shown in FIGS. **1**A and **1**B, the headphones **202**, **204** are physically connected by a headband **206**. Some users find wearing a headband to be uncomfortable and/or disruptive to their headdress or coiffure.

[0007] One way to avoid the drawbacks associated with use of a headband is to use a pair of conventional wired earbuds. An earbud is a small headphone that fits into the concha of the pinna of the user's ear. FIG. **3** shows a user **300** wearing a pair of wired earbuds **302**, **304**. A pair of electrical cables **306**, **308** connects transducers within the earbuds **302**, **304** to an external audio source. A cable clip **310** may also be used to secure the electrical cables **306**, **308** so that they do not interfere with the movement of the user **300** and to prevent tangling of the electrical cables **308**, **310**. While use of earbuds does avoid the drawbacks of having to wear a headband, their use still requires cabling (i.e. wires) between the earbuds and the external audio device.

[0008] Another type of headset that avoids the use of a headband is the Bluetooth enabled over-the-ear wireless headset. This type of headset is known in the art as a "monaural" headset, since it operates with only one of the user's two ears. FIG. **4** is an illustration of a user **400** wearing a Bluetooth enabled over-the-ear wireless headset. The headset includes a headphone **402** and an earloop **404** that is configured to fit around the outer ear of the user **400**. The headphone **402** includes a single audio transceiver for placement near the ear and a voice tube **406** for directing sound from the user's voice to a microphone within the headphone housing. The single audio transceiver communicates with an external wireless audio device **408** (e.g., a cellular telephone) over a wireless link **410**.

[0009] Because the Bluetooth enabled over-the-ear wireless headset is monaural, it is incapable of providing high-fidelity stereo audio to the user **400**. For this reason, such devices are used primarily for enabling hands-free operation of a mobile telephone and not for listening to music.

[0010] Each of the various types of prior art headsets described above has its own unique benefits and drawbacks. For example, a benefit of the conventional wired binaural headsets in FIGS. **1**A and **1**B are that they are relatively inexpensive to manufacture and acquire. A benefit of the binaural Bluetooth enabled headset in FIG. **2** is that it is wireless and provides stereo audio. Unfortunately, each of these three types of headsets requires the use of a headband and/or an electrical connection (i.e., electrical wiring) between the two headphones of the headset. The earbud type headset is beneficial in that it obviates the need for a headband. However, the earbuds are also wired, i.e., require cabling to electrically connect the transducers in the earbuds to an external audio device. Finally, whereas the Bluetooth enabled over-the-ear wireless headset avoids both the need

for a headband and the need for cabling to connect to an external audio device, it is, unfortunately, monaural. Consequently, it is incapable of providing high-quality stereo sound to a user.

BRIEF SUMMARY OF THE INVENTION

[0011] Wireless systems having a plurality of physically and electrically-separated data sinks are disclosed. An exemplary wireless system includes first and second data sinks having no physical or electrical connection therebetween. The first and second data sinks each include a wireless communication device, e.g., a radio frequency (RF) receiver or transceiver configured to receive data signals over one or more single-access wireless links or over a multi-access wireless link. The first and second data sinks in exemplary embodiments described herein comprise audio data sinks, e.g., left-ear and right-ear earphones (e.g., earbuds or canalphones), left-ear and right-ear circum-aural over-the-ear headphones, stereo speakers, speakers for a surround sound system, etc. At least one of the first and second data sinks may also be coupled to a wireless transmitter and accompanying data source (e.g., a microphone or sensor), so as to provide, for example, two-way communications between a user and an external data device (e.g., a cellular telephone). Those of ordinary skill in the art will readily appreciate and understand that the inventions defined by the claims attached hereto are not be limited to or by the summary of the exemplary embodiments provided here or to or by the detailed description of the exemplary embodiment set forth below.

[0012] Further features and advantages of the present invention, as well as the structure and operation of the various exemplary embodiments of the present invention, are described in detail below with respect to accompanying drawings, in which like reference numbers are used to indicate identical or functionally similar elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1**A is an illustration of a user wearing a prior art headset comprising a pair of headphones connected by a headband, where both headphones are connected to a pair of cables leading to an external audio source;

[0014] FIG. **1**B is an illustration of a user wearing a prior art headset comprising a pair of headphones connected by a headband, where only one of the pair of headphones is connected to a cable leading to an external audio source, and where the headphones are electrically coupled by wiring within the headband of the headset;

[0015] FIG. **2** is an illustration of a user wearing a prior art binaural Bluetooth enabled headset having a headband that physically connects the two headphones of the headset;

[0016] FIG. **3** is an illustration of a user wearing a pair of prior art wired earbuds;

[0017] FIG. **4** is an illustration of a user wearing a prior art Bluetooth enabled over-the-ear monaural wireless headset;

[0018] FIG. **5** is an illustration of a user wearing a wireless headset comprising first and second wireless earphone, in accordance with an embodiment of the present invention;

[0019] FIG. **6** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0020] FIG. **7**A is a diagram of a two-stage transmitter that may be used to implement each of the first and second transmitters in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0021] FIG. **7**B is a diagram of a direct conversion transmitter that may be used to implement each of the first and second transmitters in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0022] FIG. **8**A is a diagram of a superheterodyne receiver that may be used to implement each of the first and second receivers in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0023] FIG. **8**B is a diagram of a direct conversion receiver that may be used to implement each of the first and second receivers in the wireless system shown in FIG. **6**, in accordance with embodiments of the present invention;

[0024] FIG. **9** is a diagram of an RF transceiver that may be used in place of one or more of the RF transmitters and receivers of the various disclosed embodiments, in accordance with embodiments of the present invention;

[0025] FIG. **10** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0026] FIG. **11** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0027] FIG. **12** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention;

[0028] FIG. **13** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention; and

[0029] FIG. **14** is a diagram showing a wireless system that may be used to wirelessly transmit data signals to two or more data sinks, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0030] FIG. **5** is an illustration of a user **500** wearing a wireless headset comprising first and second wireless earphones **502**, **504**, in accordance with an embodiment of the present invention. Each of the first and second wireless earphones **502**, **504** comprises a housing containing a speaker, an RF receiver or transceiver and a battery. The speaker may comprise, for example, a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements. As explained in detail below, the receiver or transceiver of each of the first and second earphones **502**, **504** is operable to communicate with one or more external data or audio data devices (e.g., a cellular telephone, PDA, MP3 player, CD player, radio, personal computer, game console, etc.) over one or more wireless links. Each of the first and second earphones **502**, **504** may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear; a canalphone, which can be fitted within the ear canal of the user's ear; an over-the-ear circum-aural type headphone; or any other suitable configuration that may be attached to, worn on, or fitted within the user's ear. Each of the first and

second earphone **502**, **504** may further include a clip, earloop, or other suitable securing mechanism to help maintain the earphone **502** or **504** on the ear of the user. Either or both of the first and second earphones **502**, **504** may further be coupled to a second data or audio data source such as, for example, a sensor or a microphone for capturing sound waves generated by the user's **500** voice.

[0031] FIG. **6** is a diagram showing a wireless system **600** that may be used to wirelessly transmit data signals to first and second data sinks **602**, **606**, in accordance with an embodiment of the present invention. According to this and other exemplary embodiments of the invention, the data signals may comprise audio data signals, and the first and second data sinks **602**, **606** may correspond to the first and second earphones **502**, **504** in FIG. **5**. The first data sink **602** is electrically coupled to a first radio frequency (RF) receiver **604** and the second data sink **606** is electrically coupled to a second RF receiver **608**. The first and second RF receivers **604**, **608** may be analog or digital receivers.

[0032] A first RF transmitter **610** is adapted to be wirelessly coupled to the first RF receiver **604** over a first single-access wireless link **612**, and a second RF transmitter **614** is adapted to be wirelessly coupled to the second RF receiver **608** over a second single-access wireless link **616**. The first and second RF transmitters **610**, **614** may be analog or digital transmitters. Further, in an alternative embodiment, one or more of the first and second RF receivers **604**, **608** and first and second RF transmitters **610**, **614** may comprise one or more RF transceivers, which allow communication in both directions of the first and second single-access wireless links **612**, **616**.

[0033] The first and second RF transmitters **610**, **614** are adapted to receive data signals from a data source **618**. The data source **618** may comprise a digital data source or an analog data source. For example, the data source **618** may be provided from a digital audio data output of an MP3 player, CD player, PC, PDA, mobile telephone, game console, component of an entertainment system, etc. If the data source **618** is an analog data source, and the RF transmitters **610**, **614** are digital transmitters, an analog-to-digital converter (A/D converter) may be provided, either as part of the processing circuitry of the RF transmitter **610** or external to the RF transmitter **610**, to convert the analog data signals to digital data signals.

[0034] In the wireless system **600** shown in FIG. **6**, the data source **618** is electrically coupled to both the first and second transmitters **610**, **614**, as indicated by the "CH **1**" and "CH **2**" labels in the drawing. According to an exemplary embodiment, the data provided by the data source **618** comprises first and second digital data streams having data packets formatted in compliance with any one of various wireless technologies. For example, Gaussian Frequency-Shift Keying (GFSK) or Frequency-Shift Keying (FSK) are two exemplary modulation schemes that may be used to. The baseband portions of the first and second RF transmitters **610**, **614** may also be configured to operate on the data packets to provide error correction, source encoding and/or channel encoding for error minimization, compression and/or data redundancy purposes.

[0035] According to an aspect of the invention, the baseband portion of the first and second RF transmitters **610**, **614** in the embodiment of the invention shown in FIG. **4**, as well as in other embodiments in this disclosure, process and configure the incoming data from the data source **618** into data packets compliant with the Bluetooth radio standard. Details concerning the Bluetooth radio standard may be found in "Bluetooth End-to-End" by Dee Bakker, Diane McMichael Gilster and Ron Gilster, Hungry Minds, Inc., 2002 (ISBN: 0-7645-4887-5), which is incorporated into this disclosure by reference. Those of ordinary skill in the art will readily appreciate and understand that, whereas the Bluetooth radio standard may be used, that other low power radio standards and communication protocols may alternatively be used.

[0036] As shown in FIG. **6**, the data signals from the data source **618** are separated into first and second data streams. The first and second data streams are modulated onto RF carriers by the first and second RF transmitters **610**, **614** and wirelessly transmitted to the first and second RF receivers **604**, **608**, via the first and second single-access wireless links **612**, **616**. Upon receiving the first and second data streams, the first and second RF receivers **604**, **608** down-convert the modulated RF carriers and electrically couple the demodulated first and second data streams to the first and second data sinks **602**, **606**. The baseband portions of the first and second RF receivers **604**, **608** may also contain, if necessary, a digital-to-analog (D/A) converter and/or other or additional processing circuitry to facilitate the electrical coupling of the first and second RF receivers **604**, **608** to the first and second data sinks **602**, **606**. Alternatively, such components may be included as part of the data sinks **602**, **606** themselves. These additional conversion and signal processing aspects may also be applied to other embodiments of the invention disclosed herein.

[0037] If the first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** are implemented as digital transmitters and receivers, the first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** may include data buffers to compensate data packet losses. To compensate for data packet losses, which may be caused by, for example, radio interference, data buffers may be included in each of the first and second RF transmitters **610**, **614**. Accordingly, if a data packet is lost or for some reason not received by an intended one of the first and second RF receivers **604**, **608**, the receiver not receiving the data packet may request a resend (ARQ). So long as the communication rate between the requesting receiver and the corresponding transmitter is faster than the data consumption rate of the receivers, the resending of the data packet results in no loss of information to the corresponding data sink **602** or **604**.

[0038] Timing differences between the first and second data streams may also be of concern, particularly in applications where the data packets comprise audio data. Audio data can be monophonic or stereophonic. In either case, a listener does not perceive delay differences (differential latency) between the left and right speakers (i.e., left and right data sinks **602**, **604**), so long as the audio data packets in the first and second data streams arrive at the first and second data sinks **602**, **606** within about 100 μs of each other. Nevertheless, in some circumstances either or both of the analog-to-digital (A/D) converters of the first and second RF receivers **604**, **608** may consume data faster or slower than the data provided by the first and second RF transmitters **610**, **614**. If either one of the A/D converters is too slow, data sent by the corresponding one of the first and second RF transmitters **610**, **614** will be lost at the sending end since the data has no place to go. On the other hand, the A/D converter

will stall if it operates too fast, since it will run out of data faster than data is provided to it.

[0039] There are a number of ways to compensate for differential latencies between the first and second data streams. One way is to include data buffers in each of the first and second RF receivers **604**, **608** and control the buffers so that they maintain a predetermined constant occupancy. So, for example, if the data occupancy of a data buffer of one of the first and second RF receivers **604**, **608** becomes too low (e.g., due to a fast A/D converter), interpolated or repeated data samples may be inserted into the data buffer to increase the data occupancy of the buffer, thereby forcing the buffer to maintain the intended predetermined data occupancy. Conversely, if the data occupancy of the data buffer becomes too high (e.g., due to a slow A/D converter) data samples may be removed from the buffer to reduce the data occupancy.

[0040] Another way to synchronize the first and second data streams (i.e., reduce the differential latency of the first and second data streams) is to embed the data sample clock used by the first and second RF transmitters **610**, **614** in the RF carrier signals used to carry the first and second data streams over the first and second wireless links **612**, **616**. This may be accomplished by, for example, modulating each of the RF carrier signals associated with the first and second RF transmitters **610**, **614** with analog subcarrier signals, which are synchronized with the data source sample clock used at the transmitting end of the system **600**. The subcarrier signals can be detected by the respective first and second RF receivers **604**, **608** and converted into digital clocks which can drive the A/D converters of the first and second RF receivers **604**, **608**.

[0041] Yet still another way to reduce the differential latency of the first and second data streams is to exclusive OR a pseudo-random noise sequence (PRNS) into the digital modulation of the carrier signals, similar to as is used by the TIA/IS-95 radio standard. If the PRNS used for the first and second data streams is sufficiently long, the PRNS can be correlated at the first and second RF receivers **604**, **608**, and the delay between the send and receive clocks can be deduced.

[0042] Finally, but not necessarily lastly, the differential latency between the first and second data streams may be reduced by monitoring the data buffers or delays, and adjusting the clock signals used by the A/D converters of the first and second RF receivers **604**, **608**. Accordingly, if the occupancy of a data buffer of one of the first and second RF receivers **604**, **608** is too low (or the receive clock/sample clock delay is decreasing), the A/D clock is slowed down. Conversely, if it is determined that the occupancy of the data buffer is too high (or the delay is increasing), the A/D clock is sped up.

[0043] The first and second RF transmitters **610**, **614** and first and second RF receivers **604**, **608** may be implemented in various ways. Below is a description of a few examples of how the transmitters and receivers may be implemented. Those of ordinary skill in the art will appreciate and understand that these transmitter and receiver implementations are provided here for illustrative purposes only and that other types of transmitters and receivers may alternatively be used.

[0044] FIG. **7**A is a diagram of a two-stage (heterodyne) transmitter **700** that may be used to implement each of the first and second transmitters **610**, **614** in the wireless system **600** in FIG. **6**. The two-stage transmitter **700** comprises a quadrature modulator **702**, a first band-pass filter **704**, an RF upconverter **706**, a second band-pass filter **708** an RF power amplifier **710**, and an antenna **712**. The quadrature modulator **702** is operable to receive in-phase (I) and quadrature (Q) channels of the first data stream from the data source **618** and upconvert the data to an intermediate frequency (IF). If necessary, data from the data source **618** may be coupled to a signal conditioning circuit **701** to provide analog-to-digital conversion, filtering, amplification and/or other signal processing functions, before the data is coupled to the baseband portion (i.e., baseband processor **703**) of the transmitter **700**. The first band-pass filter **704** suppresses harmonics generated by the IF modulation process and provides the filtered output to the RF upconverter **706**, which operates to upconvert the filtered IF signal to RF. The second band-pass filter **708** removes unwanted sidebands generated by the RF upconversion process and couples the filtered output to an input of the RF power amplifier **710**. The RF power amplifier **710** amplifies the filtered signals and couples the data modulated RF signal to the antenna **712**, which radiates the modulated RF signal to the first RF receiver **604** over the first single-access wireless link **612**. A second two-stage transmitter operates similarly to upconvert and modulate the I and Q channels of the second data stream from the data source **618** onto an RF carrier signal, which is radiated to the second RF receiver **608** over the second single-access link **616**.

[0045] FIG. **7**B is a diagram of a direct conversion (homodyne) transmitter **750** that may be used to implement each of the first and second transmitters **610**, **614** in the wireless system **600** in FIG. **6**. The direct conversion transmitter **750** comprises a quadrature modulator **752**, a band-pass filter **754**, an RF power amplifier **756**, and an antenna **758**. Rather than using two two-stage transmitters **700** to upconvert the first and second data streams to RF, as is may be done with the two-stage transmitter **700** in FIG. **7**A, two direct conversion transmitters **750** may be used. By using a local oscillator frequency that is equal to the RF carrier frequency, the two direct conversion transmitters are operable to directly upconvert the first and second data streams to modulated RF carriers in a single upconversion process.

[0046] FIG. **8**A is a diagram of a superheterodyne receiver **800** that may be used to implement each of the first and second receivers **604**, **608** in the wireless system **600** in FIG. **6**. The superheterodyne receiver **800** comprises a front-end stage, an RF downconverter, an automatic gain control (AGC) amplifier **816**, and a baseband quadrature demodulator **818**. The front-end stage comprises an antenna **802**, a first band-pass filter **804**, a low-noise amplifier (LNA) **806**, and a second band-pass filter **808**. The RF dowconverter comprises a first mixer **810**, a first local oscillator **812**, and a third band-bass filter **814**.

[0047] The first band-pass filter **804** filters the modulated RF signal received by the antenna **802** to preselect the intended frequency band of interest from noise and other unwanted signals, and protects the rest of the receiver **800** from saturation by interfering signals at the antenna **802**. The LNA **806** amplifies the filtered signal and couples its output to the second band-pass filter **808**, which operates as an image reject filter, protects the RF downconverter from out-of-band interferer signals, and suppresses undesired spurious signals generated by the first mixer **810** of the RF downconverter. Filtered signals from the second band-pass

filter **808** are coupled to the mixer **810** of the RF downconverter, which operates to transfer the modulation on the RF signal to IF. Spurious products generated by the mixer **810** are filtered out by the third band-pass filter **814**. The filtered IF signal is then coupled to an input of the AGC amplifier **816**, which operates to maintain as wide a dynamic range as possible for varying levels of RF received by the receiver **800**. The baseband quadrature demodulator **818** extracts the baseband signals from the IF. The extracted baseband signals are digitized by analog-to-digital (A/D) converters **820**, **822** and transmitted to a baseband processor **824**. Processed data from the baseband processor **824** is then coupled to the first and second data sinks. To ensure that the processed data is in a form suitable to drive the first and second data sinks **602**, **606**, the processed data from the baseband processor **824** may be first coupled to a signal conditioning circuit **826** to provide digital-to-analog conversion, filtering, amplification, and/or other signal processing functions.

[0048] The first and second receivers **604**, **608** in the wireless system **600** in FIG. **6** may alternatively be downconverted using a direct conversion (or "zero IF") receiver. FIG. **8**B is a diagram of a direct conversion receiver **850** that may be used to implement these functions. The direct conversion receiver **850** operates similar to the superheterodyne receiver **800** in FIG. **8**A except that the conversion is performed in one step. Because the RF signals are downconverted in a single operation, there is no need for an image reject filter (second band-pass filter **808** in FIG. **8**A) at the front end of the receiver **850**.

[0049] Whereas the wireless system **600** above has been described as comprising RF transmitters and RF receivers, in an alternative embodiment RF transceivers containing both an RF transmitter and an RF receiver may be used in place of each of the RF transmitters **610**, **614** and RF receivers **604**, **608**. The same alteration is also applicable to the other embodiments set forth in this disclosure. FIG. **9** is a block diagram of an RF transceiver **900** that may be used for this purpose. The RF transceiver **900** comprises an RF transmitter portion **902**, an RF receiver portion **904**, an antenna **906**, and a duplexer **908**. The duplexer **908** operates to isolate the transceiver portion **904** from the transmitter portion **902**. An A/D converter **910** receives downconverted analog baseband signals from the RF transceiver portion **904**, digitizes the signals, and sends the digitized baseband signals to a baseband processor **914**. If necessary, the processed data from the baseband processor **914** may be coupled to a signal conditioning circuit **916** to provide digital-to-analog conversion, filtering, amplification, and/or other signal processing functions, to ensure that the processed data is in a form suitable to drive the data sink **918**.

[0050] For the RF transmitter portion **902**, a D/A converter **912** is adapted to receive data signals from a data source **922** and operable to convert the data signals into analogs signals, which are upconverted to RF by the RF transmitter in preparation of being radiated over the appropriate wireless link by the antenna **906**. If necessary, data from the data source **922** may be coupled to a signal conditioning circuit **920** to provide analog-to-digital conversion, filtering, amplification and/or other signal processing functions, before the data is coupled to the baseband processor **914**.

[0051] While the exemplary RF transceiver **900** in FIG. **9** has been shown and described as comprising an RF transmitter portion **902** and an RF receiver portion **904** that share the same antenna and use a common wireless technology, an alternative RF transceiver design may comprise an RF transmitter portion and receiver portion configured to use separate antennas. The RF transceiver may further include additional circuitry and processing capabilities that allow the RF transmitter and receiver portions to operate in accordance with different wireless technologies.

[0052] As discussed above, the wireless system **600** in FIG. **6** uses a separate transmitter/receiver pair or transceiver/transceiver pair (if transceivers are used) for each channel. Because each transmitter/receiver pair is dedicated to a single channel, the data rate in each channel can be lower than the data rate that would be necessary if both of the separated data streams were transmitted over each wireless link **612**, **616**. The lower data rate over the first and second single-access wireless links **612**, **616** allows the use of more economical electrical components, and allows the system components to operate at lower power levels. Furthermore, this embodiment of the present invention allows for independent power control of the transmitter/receiver or transceiver/transceiver pairs, which allows each transmitter/receiver or transceiver/transceiver pair to consume only as much power as is required to communicate.

[0053] In some applications, however, it may not be possible to reduce the data rate, or it may be desirable for one reason or another to maintain both the first and second data streams on the same wireless link. If such circumstances arise, the wireless system **1000** shown in FIG. **10** may be used. According to this embodiment of the invention, data for both the first and second data sinks **1016**, **1018** (e.g., audio data intended for both the right-ear and left-ear earphones **502**, **504**) are both transmitted on each of single-access wireless links **1004**, **1006**. The first and second receivers **1008**, **1010** are each configured to receive both the first and second data streams from the first and second transmitters **1012**, **1014** and couple only the appropriate one of the data streams to the first and second data sinks **1016**, **1018** of the system. Compensation for data packet loss and differential latency of the first and second data streams may be accomplished using techniques similar to those described above for the embodiment shown in FIG. **6**. Further those techniques, or similar techniques, may be applicable to other embodiments disclosed herein.

[0054] According to an alternative embodiment of the invention shown in FIG. **11**, a single source transmitter (or source transceiver) **1102** may be used to broadcast data from the data source **1112** to first and second RF receivers **1106**, **1108**, instead of the first and second transmitters **1012**, **1014** used in the embodiment shown in FIG. **10**. Those of ordinary skill in the art will readily appreciate and understand that the wireless system **1100**, as well as the other embodiments set forth in this disclosure, may comprise either analog or digital radio techniques. In the case of a digital implementation, differential latency of data received by the first and second RF receivers **1106**, **1108** may be reduced or maintained at a predetermined level by including data buffers in the first and second RF receivers **1106**, **1108**. By controlling and maintaining the data occupancy of the data buffers at some constant predetermine data occupancy level, similar to that described above in connection with the embodiment shown in FIG. **6**, the differential latency can be reduced or maintained at predetermined levels.

[0055] Referring now to FIG. **12**, there is shown a wireless system **1200** that may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., first

and second earphones **502**, **504** in FIG. **5**), in accordance with an alternate embodiment of the present invention. The wireless system **1200** includes a single RF transmitter **1210**, which is adapted to be wirelessly coupled to an RF transceiver **1204** over a first single-access wireless link **1212**. The RF transmitter **1210** operates to wirelessly transmit data streams intended for both the first and second data sinks **1202**, **1206** to the RF transceiver **1204**. The RF transceiver **1204** receives the data modulated onto the RF carrier, downconverts the data modulated RF carrier, and couples the data needed only for operation of the first data sink **1202** (e.g., right channel stereo indicated as "CH **1**" in the drawing) to the first data sink **1202**. A transmitter portion of the RF transceiver **1204** transmits data needed only for the operation of the second data sink **1206** to an RF receiver **1208** over a second single-access wireless link **1213**. The RF receiver **1208** operates to downconvert the data modulated signal and couple the downconverted data to the second data sink **1206**. Communication between the transmitter portion of the RF transceiver **1204** and the receiver **1208** may be conducted in accordance with the same or similar wireless technology as used by the source transmitter **1210** and the receiver portion of the RF transceiver **1204**, or may use a different wireless technology. As in other embodiments disclosed herein, the receiver portion of the RF transceiver **1204** and the receiver **1208** may include data buffers that are controlled to compensate for, or reduce the differential latency of, data arriving at the first and second data sinks **1202**, **1206**. In particular, the data buffer occupancies of the RF transceiver **1204** and/or the receiver **1208** can be controlled to compensate for the delay imparted to the data routed through the RF receiver **1208**, so that the differential latency between data arriving at the first data sink **1202** and data arriving at the second data sinks **1206** is reduced or controlled to within some predetermined threshold.

[0056] According to an embodiment of the invention, either or both the first and second data sinks of the various embodiments may include (or be coupled to) a data source such as, for example, a sensor or a microphone to allow a data to be sent back to an external electronic device. FIG. **13** shows a wireless system **1300** that may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., the first and second earphones **502**, **504** in FIG. **5**, and also provide data signals back to the external electronic device, in accordance with an alternate embodiment of the present invention. The wireless system **1300** comprises first and second data sinks **1302**, **1306**, which are electrically coupled to an RF receiver **1304** (or transceiver) and a first RF transceiver **1308**, respectively. A second RF transceiver **1310** is adapted to be wirelessly coupled to the RF receiver **1304** and the first RF transceiver **1308**. The second RF transceiver **1310** is adapted to receive data from a data source **1314** and broadcast an RF carrier, which is modulated by the data, to both the receiver **1304** and the first RF transceiver **1308**. The second RF transceiver **1310** is also adapted to receive data modulated carrier signals (e.g., voice data modulated carrier signals) in the reverse direction from the first RF transceiver **1308**, which receives data signals from a data source **1312** comprising, for example, a sensor or a microphone. The data modulated signals are downconverted by the second RF transceiver **1310** and coupled to a data source/data sink **1314**. The data signal extracted may then be provided as data signals to an external electronic device, e.g., an external audio device. Those of ordinary skill in the art will readily appreciate and understand that a similar data source may also be incorporated in any on of the other embodiments described in this disclosure.

[0057] Those of ordinary skill in the art will readily appreciate and understand that the wireless system **1300**, as well as the other embodiments set forth in this disclosure, may comprise either analog or digital radio techniques. In the case of a digital implementation, differential latency of data received by the RF receiver **1304** and the receiver portion of the first RF transceiver **1308** may be reduced or maintained at a predetermined level by including data buffers in the RF receiver **1304** and the receiver portion of the first RF transceiver **1308**. By controlling and maintaining the data occupancy of the data buffers at some constant predetermine data occupancy level, similar to that described above in connection with the embodiment shown in FIG. **6**, the differential latency can be reduced or maintained at predetermined levels.

[0058] FIG. **14** is a diagram of a wireless system **1400**, in accordance with another embodiment of the present invention. Similar to the previously described embodiments, the wireless system **1400** may be used to provide data signals (e.g., audio data signals) to first and second data sinks (e.g., to the first and second earphones **502**, **504** in FIG. **5**). The wireless system **1400** includes a single multi-access RF transmitter (or transceiver) **1410**, which is adapted to be wirelessly coupled to first and second multi-access RF receivers (or transceivers) **1404**, **1408** over a multi-access wireless link **1412**. Data packets from a data source are separated (or "multiplexed") by use of distinct codes or time slots that are uniquely assigned to the first and second RF receivers **1404** and **1408**. The multi-access RF transmitter **1410** transmits the data packets according to the time slots or codes over the multi-access wireless link **1412**. The RF receivers **1404**, **1408** operate to extract and downconvert their intended data packets based on the time slots or codes uniquely allocated to them. Those of ordinary skill in the art will readily appreciate that, similar to the embodiments described above, the first and second RF receivers **1404**, **1408** may include data buffers that are controlled so that the data provided to the first and second data sinks **1402**, **1404** have a differential latency that is at or below a predetermined threshold.

[0059] Any one of a number of multi-access data protocols may be employed by the wireless system **1400**. As an example, time domain multiple access (TDMA) multiplexing may be used. TDMA multiplexes the data packets of the first and second data streams in time so that the RF transmitter **1410** may transmit the time multiplexed data packets in time slots. The first and second receivers **1404**, **1408** are synchronized with the RF transmitter **1410** so that appropriate data packets modulated on the RF carrier over the multi-access link **1412** can be extracted by the first and second RF receivers **1404**, **1408** during their allocated time slots.

[0060] Code domain multiple access (CDMA) is another multi-access data protocol that may be used in the multi-access wireless system **1400** in FIG. **14**. Rather than using time to multiplex the data packets of the first and second data streams, CDMA operates to encode, and thereby multiplex, the data packets with orthogonal codes that are uniquely assigned and known by the first and second RF receivers **1404**, **1408**. The first and second RF receivers **1404**, **1408** are then only capable of extracting data packets having the

unique codes assigned to them. Details of the CDMA and TDMA multi-access protocols may be found in "Principles of Wireless Networks: A Unified Approach" by P. Krishnamurthy and K. Pahlavan, Prentice Hall, 2002 (ISBN: 0-130-93003-2), and "RF System Design of Transceivers for Wireless Communications" by Q. Gu, Springer Science—Business Media, Inc., 2005 (ISBN: 0-387-24161-2), both which are incorporated into this disclosure by reference.

[0061] Although the present invention has been described with reference to specific embodiments thereof, these embodiments are merely illustrative, and not restrictive, of the present invention. Various modifications or changes to the specifically disclosed exemplary embodiments will be suggested to persons skilled in the art. For example, while some of the various disclosed embodiments have been described in the context of wireless systems for wireless earphones, the apparatus, systems and methods disclosed herein are applicable to any application in which a plurality of unconnected wireless data sinks is desirable. For example, the various disclosed embodiments may be used to form a home entertainment system in which the plurality of data sinks correspond to a plurality of physically unconnected wireless speakers.

[0062] Furthermore, while the various exemplary embodiments herein are described as containing first and second data sinks, those of ordinary skill in the art will readily appreciate and understand that the general concept of wireless transmission to physically unconnected wireless data sinks may be applied to wireless systems with more than two data sinks (e.g., for a fully wireless surround sound type system).

[0063] Still further, whereas the various disclosed embodiments have been described as transmitting and receiving RF signals, the transmitters, receivers and transceivers may alternatively be configured to transmit and receive according to other types of wireless techniques, e.g., optical, ultrasound, non-radiated wireless techniques such as over-the-body inductive or capacitive coupling, etc.

[0064] Accordingly, the scope of the invention should not be restricted to the specific exemplary embodiments disclosed herein, and all modifications that are readily suggested to those of ordinary skill in the art should be included within the spirit and purview of this application and scope of the appended claims.

What is claimed is:

1. A wireless system, comprising:

a first wireless receiver coupled to a first data sink; and

a second wireless receiver coupled to a second data sink,

wherein said first and second data sinks have no physical or electrical connection between them, and said first and second wireless receivers are operable to reduce a differential latency between data received by said first wireless receiver and data received by said second wireless receiver.

2. The wireless system of claim **1** wherein said first and second data sinks comprise first and second earphones adapted to fit into first and second ears of a user.

3. The wireless system of claim **1** wherein said first and second data sinks comprise first and second circum-aural headphones adapted to fit over first and second ears of a user.

4. The wireless system of claim **1** wherein said first and second data sinks comprise first and second speakers.

5. The wireless system of claim **1** wherein said first wireless receiver is configured to receive a data modulated carrier signal from a single wireless transmitter.

6. The wireless system of claim **5** wherein said second wireless receiver is also configured to receive the data modulated carrier signal from said single wireless transmitter.

7. The wireless system of claim **1** wherein:

said first wireless receiver is configured to receive a first data modulated carrier signal from a first wireless transmitter over a first single-access wireless link; and

said second wireless receiver is configured to receive a second data modulated signal from a second wireless transmitter over a second single-access wireless link.

8. The wireless system of claim **7** wherein the data modulated onto the first data modulated carrier signal is the same as the data modulated onto the second data modulated carrier signal.

9. The wireless system of claim **7** wherein the data modulated onto the first data modulated carrier signal is different from the data modulated onto the second data modulated carrier signal.

10. The wireless system of claim **1**, further comprising a wireless transmitter operable to transmit at least a subset of data received by said first one of said first and second wireless receivers to a second one of said first and second wireless receivers.

11. The wireless system of claim **10** wherein said first one of said first and second wireless receivers is adapted to receive data signals according to a first wireless technology and said second one of said first and second wireless receivers is adapted to receive data signals according to a second wireless technology.

12. The wireless system of claim **1** further comprising:

a wireless transmitter coupled to one of said first and second wireless receivers; and

a data source coupled to said wireless transmitter.

13. The wireless system of claim **12** wherein said data source comprises a sensor.

14. The wireless system of claim **12** wherein said data source comprises a microphone.

15. The wireless system of claim **1** wherein at least one of said first and second wireless receivers is configured to receive data signals in accordance with the Bluetooth radio standard.

16. The wireless system of claim **1** wherein:

said first wireless receiver is configured to receive a first data modulated carrier signal carrying data exclusively for said first data sink; and

said second wireless receiver is configured to receive a second data modulated carrier signal carrying data exclusively for said second data sink.

17. The wireless system of claim **1** wherein said first and second wireless receivers are configured to receive data modulated carrier signals from a multi-access wireless transmitter over a multi-access wireless link.

18. A wireless headphone system, comprising:

a right-ear data sink having first means for wirelessly receiving a data modulated carrier signal; and

a left-ear data sink having second means for wirelessly receiving a data modulated carrier signal,

wherein said right-ear and left-ear data sinks have no physical or electrical connection between them.

19. The wireless headphone system of claim **18**, further comprising means for reducing differential latency between data received by said first means and data received by said second means.

20. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means includes the same data as the data modulated carrier signal received by the second means.

21. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means includes data that is different from the data included in the data modulated carrier signal received by the second means.

22. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means and the data modulated carrier signal received by the second means are both transmitted from a single wireless transmitter.

23. The wireless headphone system of claim **18** wherein the data modulated carrier signal received by the first means is transmitted from a first wireless transmitter and the data modulated carrier signal received by the second means is transmitted from a second wireless transmitter.

24. The wireless headphone system of claim **18** wherein the first means and the second means are adapted to receive data modulated carrier signals from a multi-access wireless transmitter over a multi-access wireless link.

25. The wireless headphone system of claim **18**, further comprising a wireless transmitter coupled to one of said right-ear and left ear data sinks, said wireless transmitter configured to receive data from a data source.

26. The wireless headphone system of claim **25** wherein said data source comprises a sensor.

27. The wireless headphone system of claim **25** wherein said data source comprises a microphone.

28. The wireless headphone system of claim **18** wherein at least one of said first and second means is adapted to receive a data modulated carrier signal that is compliant with the Bluetooth radio standard.

29. A wireless communication system, comprising:

a first data sink coupled to a first wireless communication means;

a second data sink coupled to a second wireless communication means; and

third wireless communication means for modulating data from a first data source onto one or more carrier signals and transmitting one or more data modulated carrier signals to at least one of said first and second wireless communication means,

wherein said first and second data sinks have no physical or electrical connection between them and at least one of said first and second wireless communication means is operable to reduce a differential latency between data provided to said first data sink and data provided to said second data sink.

30. The wireless communication system of claim **29** wherein said first wireless communication means includes wireless transmission means for wirelessly transmitting at least a subset of data received by said first wireless communication means to said second wireless communication means.

31. The wireless communication system of claim **30** wherein said at least a subset of said data transmitted by said wireless transmission means to said second wireless communication means is transmitted according to a first wireless technology and data transmitted by said third wireless communication means to said at least one of said first and second wireless transmission means is transmitted according to a second wireless technology.

32. The wireless communication system of claim **29**, further comprising:

a second data source adapted to provide data to transmission means of said first wireless communication means; and

means for receiving from said transmission means a wireless carrier signal modulated by data from said second data source.

33. The wireless communication system of claim **32** wherein said second data source comprises a sensor.

34. The wireless communication system of claim **32** wherein said second data source comprises a microphone.

35. The wireless communication system of claim **29** wherein said third communication means includes a single wireless transmitter operable to modulate data from said first data source onto a single carrier signal, and broadcast the data modulated carrier signal to said first and second wireless communication means.

36. The wireless communication system of claim **29** wherein said third communication means comprises:

a first wireless transmitter operable to transmit a first carrier signal modulated by a first subset of data provided by said first data source to said first wireless communication means; and

a second wireless transmitter operable to transmit a second carrier signal modulated by a second subset of data provided by said first data source to said second wireless communication means.

37. The wireless communication system of claim **29** wherein said third wireless communication means comprises first and second wireless transmitters that are both operable to modulate data for reception by both said first and second communication means onto a single carrier signal.

38. The wireless communication system of claim **29** wherein said third wireless communication means comprises first and second wireless transmitters operable to modulate data for reception by said first and second communication means, respectively, onto first and second carrier signals.

39. The wireless communication system of claim **29** wherein:

said first data sink comprises a first earphone adapted to fit into a first ear of a user; and

said second data sink comprises a second earphone adapted to fit into a second ear of the user.

40. The wireless communication system of claim **29** wherein:

said first data sink comprises a first circum-aural headphone adapted to fit over a first ear of a user; and

said second data sink comprises a second circum-aural headphone adapted to fit over a second ear of the user.

41. The wireless communication system of claim **29** wherein said first, second and third wireless communication means comprises multi-access wireless communication means that communicate over a multi-access wireless link.

42. The wireless communication system of claim **29** wherein at least one of said first and second wireless communication means is adapted to receive a data modulated carrier signal in accordance with the Bluetooth radio standard.

* * * * *

US 20080166001A1

(19) United States
(12) Patent Application Publication
Hankey et al.
(10) Pub. No.: US 2008/0166001 A1
(43) Pub. Date: Jul. 10, 2008

(54) **HEADSET WITH MICROPHONE AND CONNECTOR CO-LOCATION**

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NEW YORK, NY 10036-8704

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(21) Appl. No.: **11/823,922**

(22) Filed: **Jun. 28, 2007**

Related U.S. Application Data

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Publication Classification

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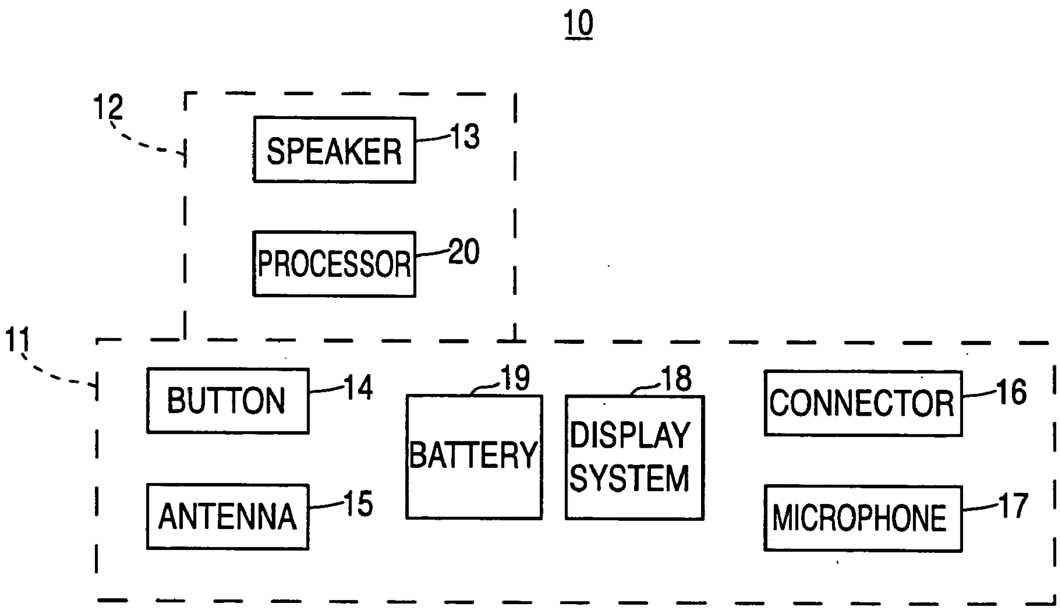
H04R 1/10 (2006.01)

(52) **U.S. Cl.** **381/364**; 381/361

(57) **ABSTRACT**

An electronic device is provided that includes a housing and a connector assembly coupled to the housing. The connector assembly can include a microphone port. The electronic device can further include a microphone mounted within the housing and a channel that fluidically couples the microphone to the microphone port. A joint connector and microphone assembly is also provided. The assembly can include a microphone with a top surface and side surfaces. The top surface of the microphone can include a microphone input. The assembly can include a microphone boot mounted to the microphone such that the boot interfaces with a portion of the top surface and the side surfaces to form a seal around the microphone input. The microphone boot can include a connector sealing portion and an aperture for fluidically coupling the microphone input to a microphone port. The assembly can include a connector plate mounted to the connector sealing portion.



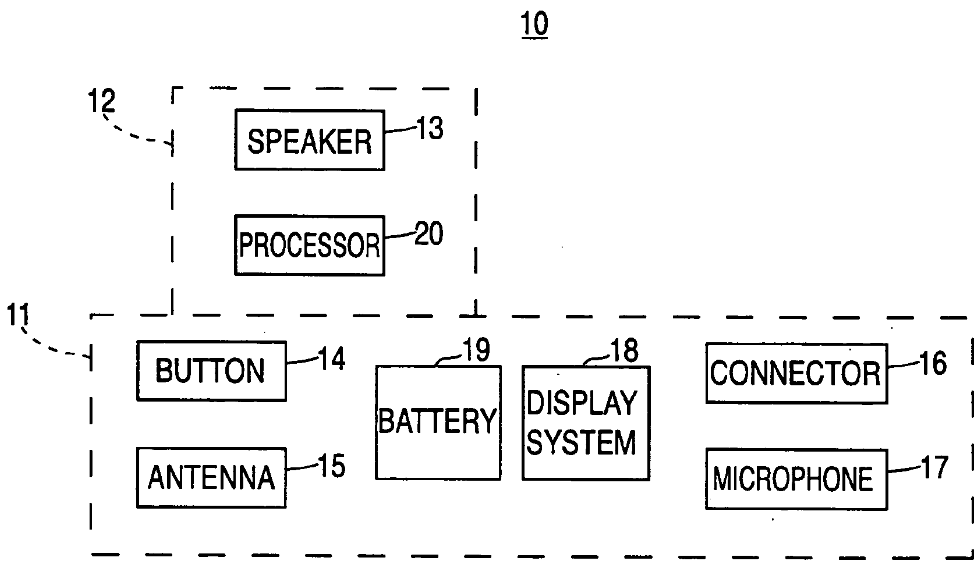

10
12
SPEAKER
13
PROCESSOR
20
11
BUTTON
14
19
18
CONNECTOR
16
BATTERY
DISPLAY SYSTEM
ANTENNA
15
MICROPHONE
17

FIG. 1

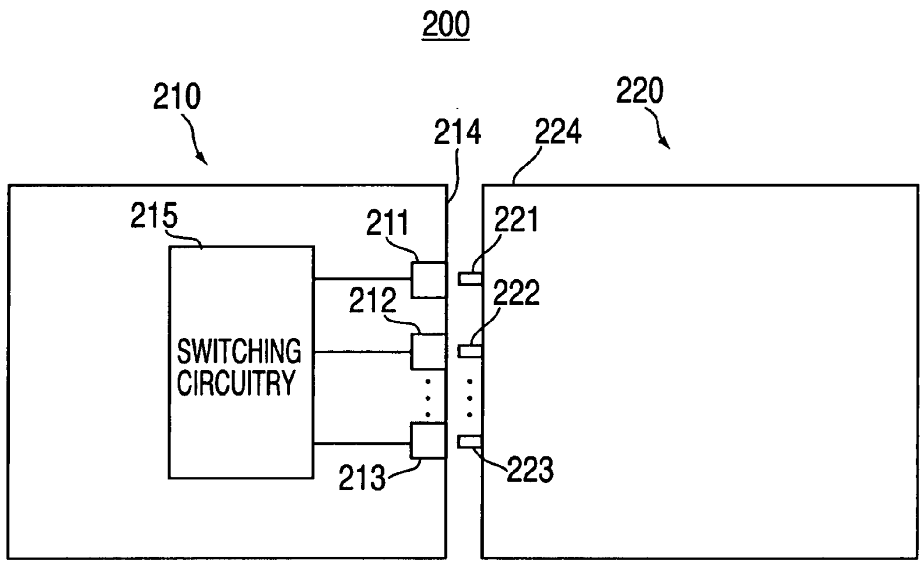

200
210
220
214
224
215
211
221
212
222
SWITCHING CIRCUITRY
213
223

FIG. 2

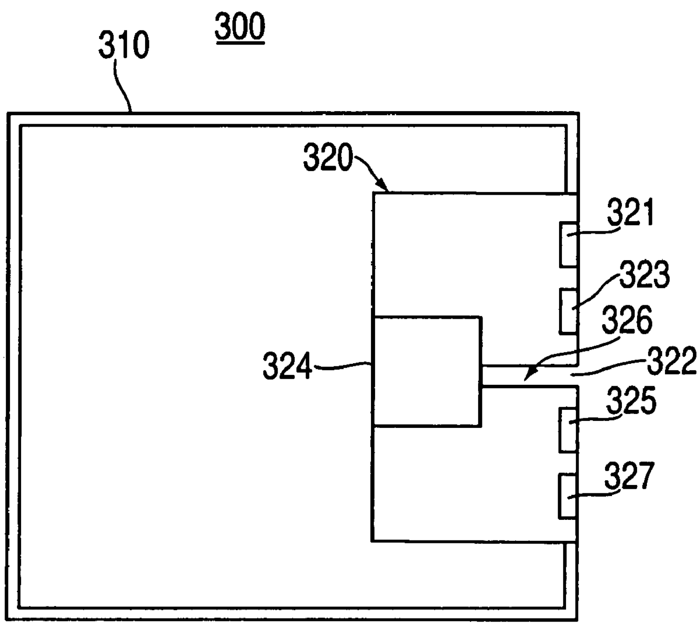

300
310
320
321
323
326
322
324
325
327

FIG. 3

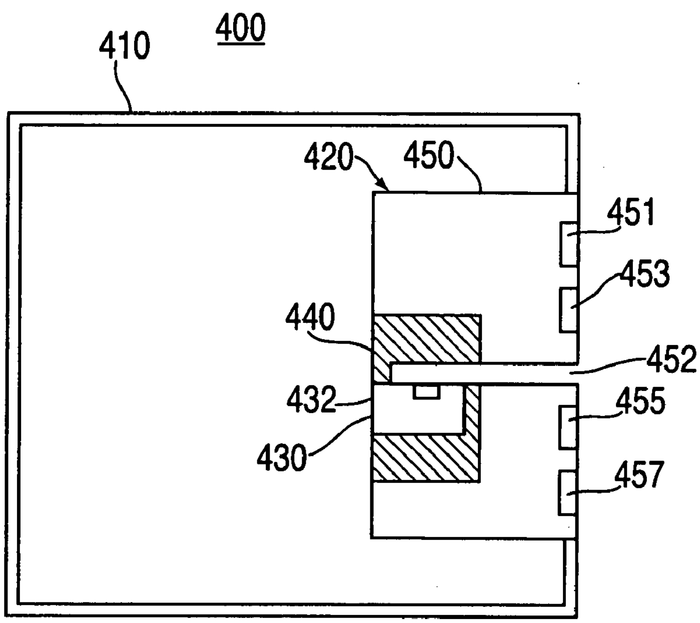

400
410
420
450
451
453
440
452
432
455
430
457

FIG. 4

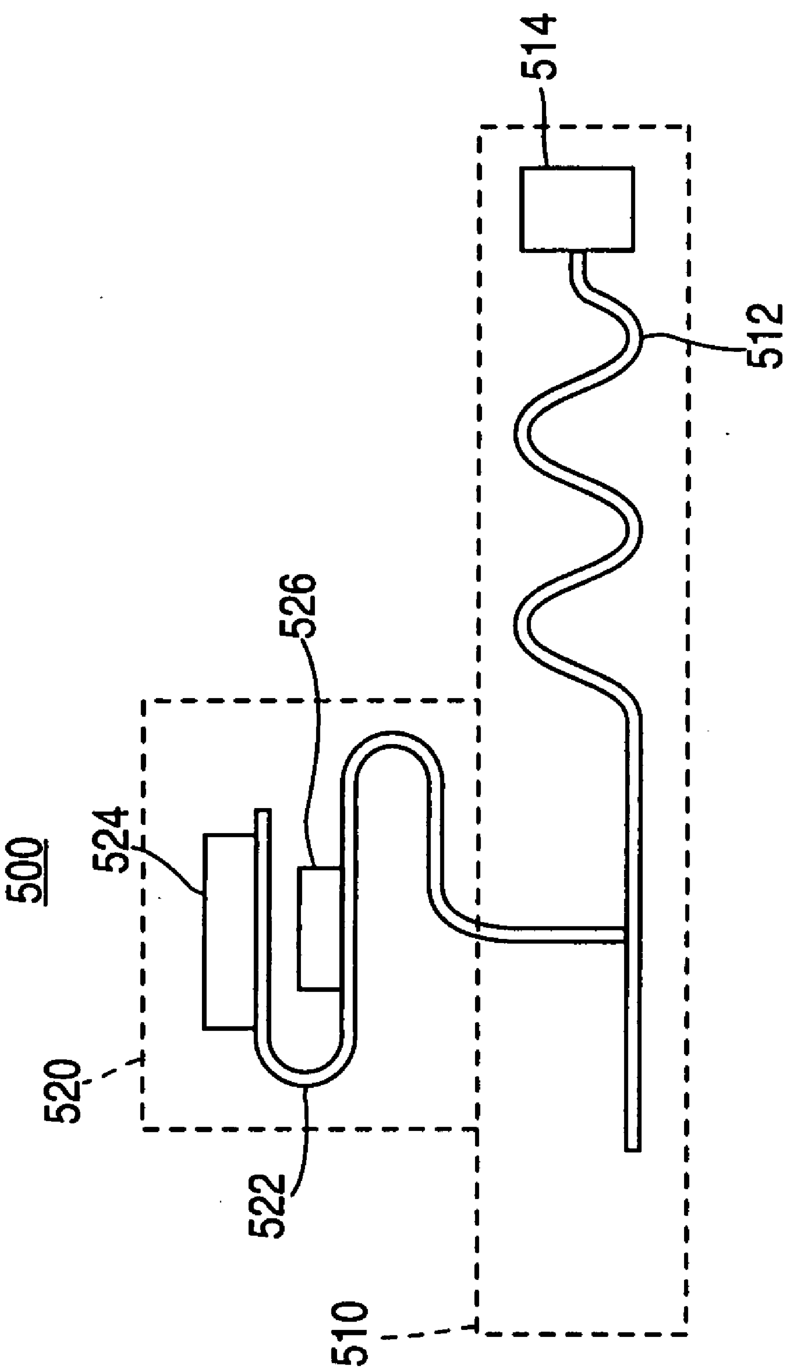


FIG. 5

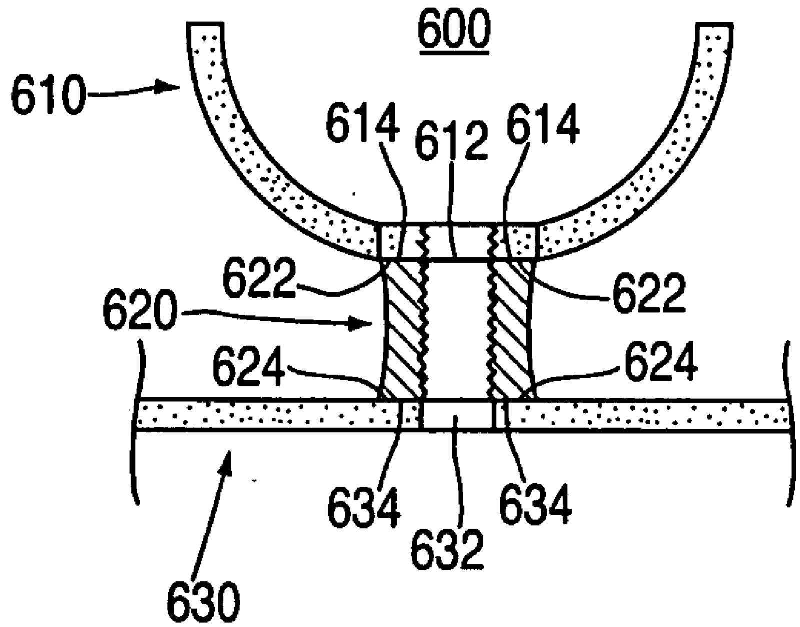

600
610
614
612
614
622
622
620
624
624
634
632
634
630

FIG. 6A

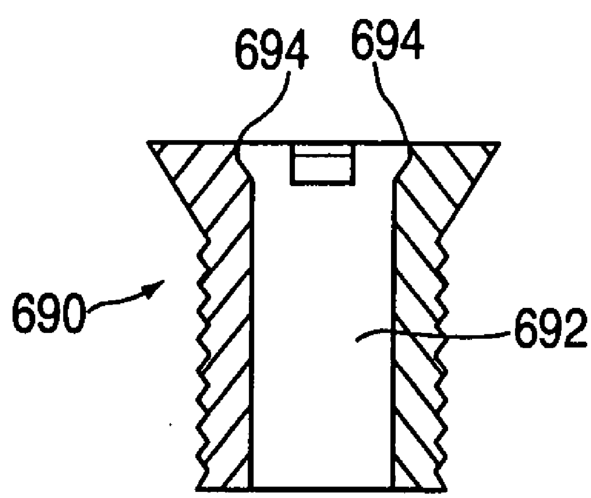

694
694
690
692

FIG. 6B

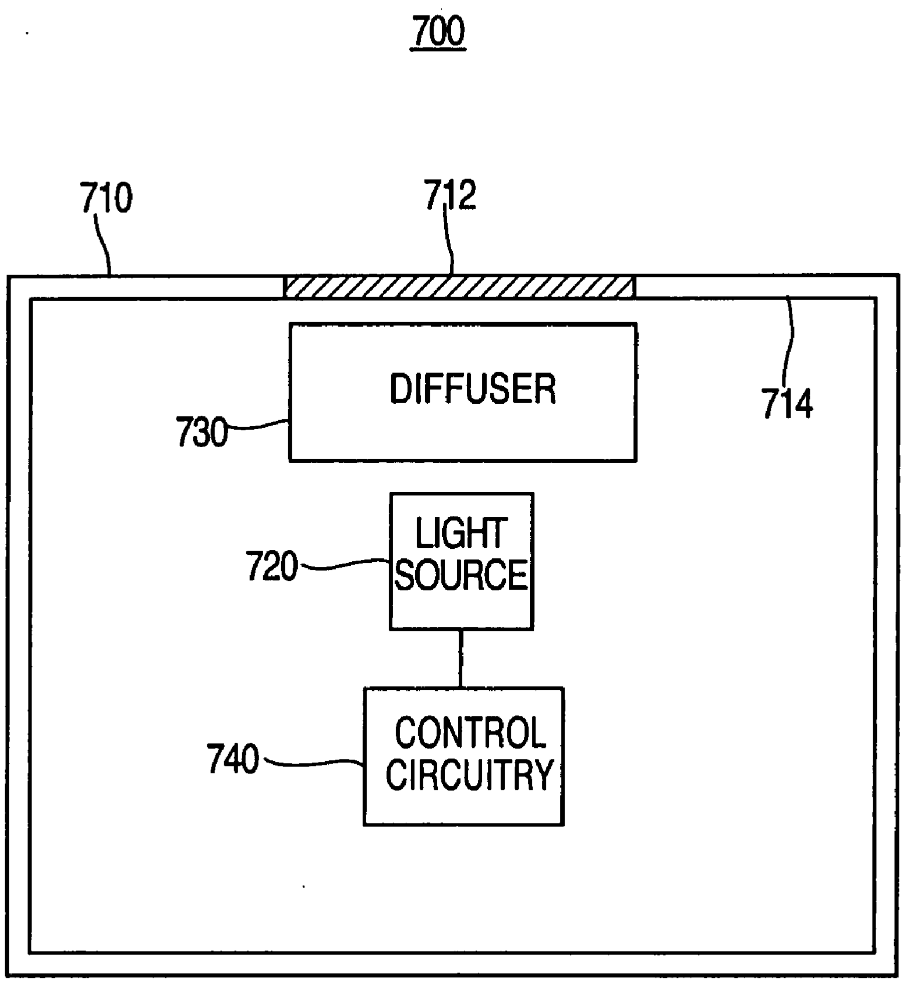

700
710
712
714
DIFFUSER
730
LIGHT SOURCE
720
CONTROL CIRCUITRY
740

FIG. 7

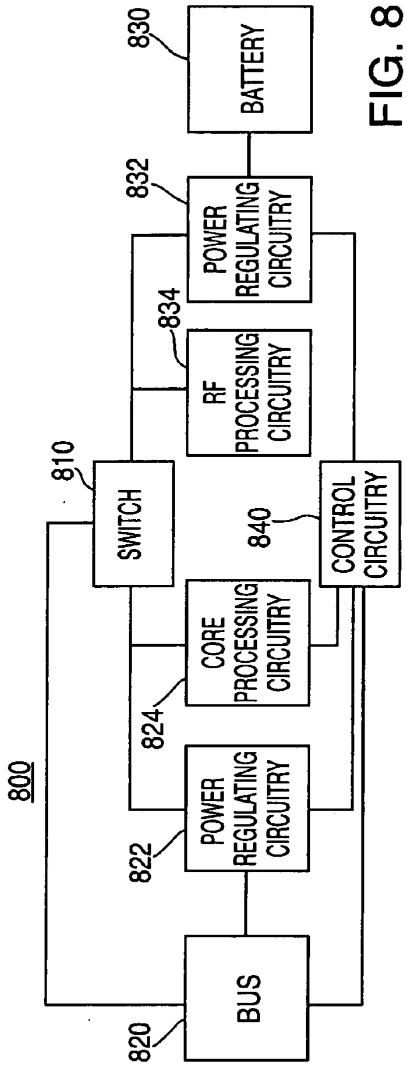

800
BUS
820
POWER REGULATING CIRCUITRY
822
CORE PROCESSING CIRCUITRY
824
SWITCH
810
CONTROL CIRCUITRY
840
RF PROCESSING CIRCUITRY
834
POWER REGULATING CIRCUITRY
832
BATTERY
830

FIG. 8

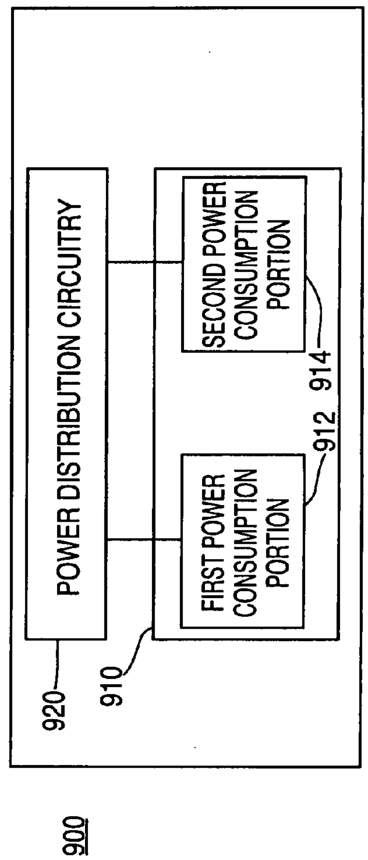

900
POWER DISTRIBUTION CIRCUITRY
920
910
FIRST POWER CONSUMPTION PORTION
912
SECOND POWER CONSUMPTION PORTION
914

FIG. 9

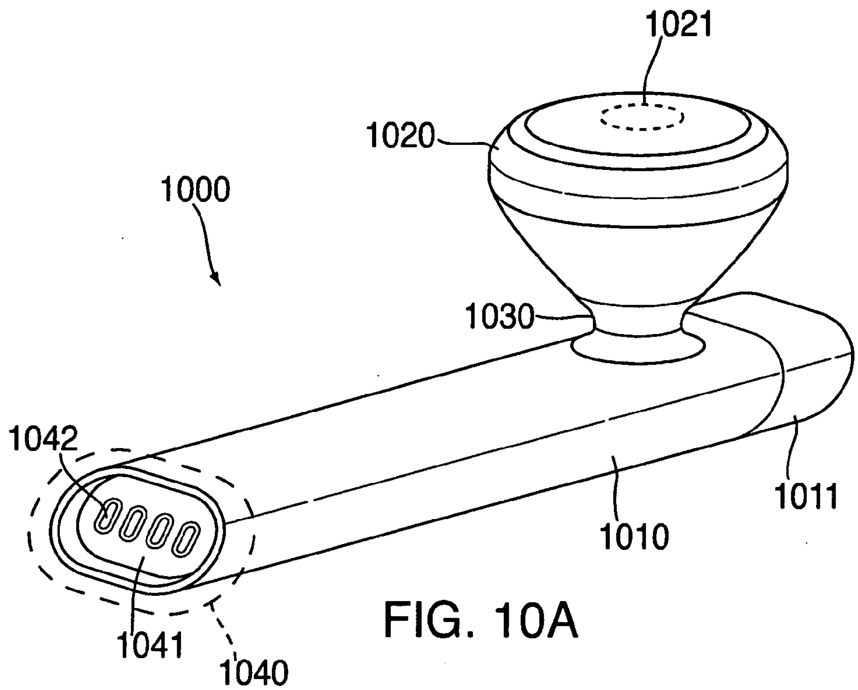


FIG. 10A

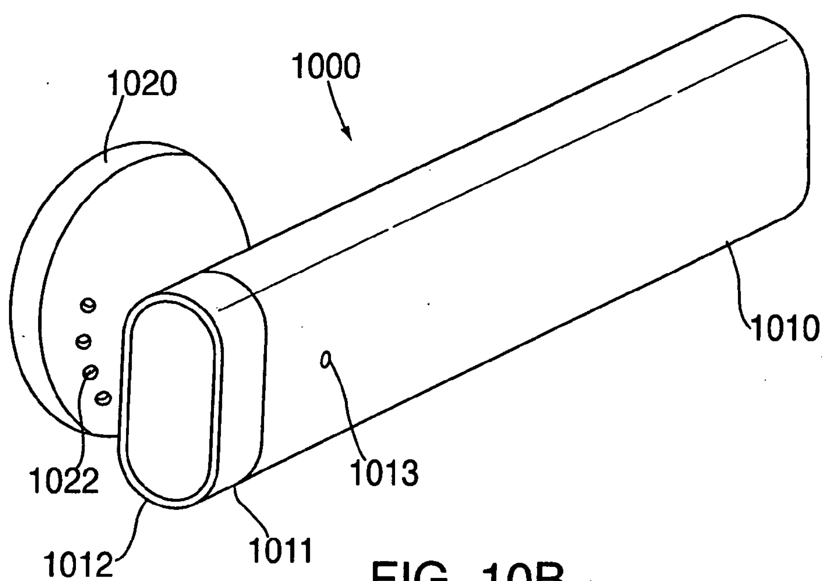


FIG. 10B

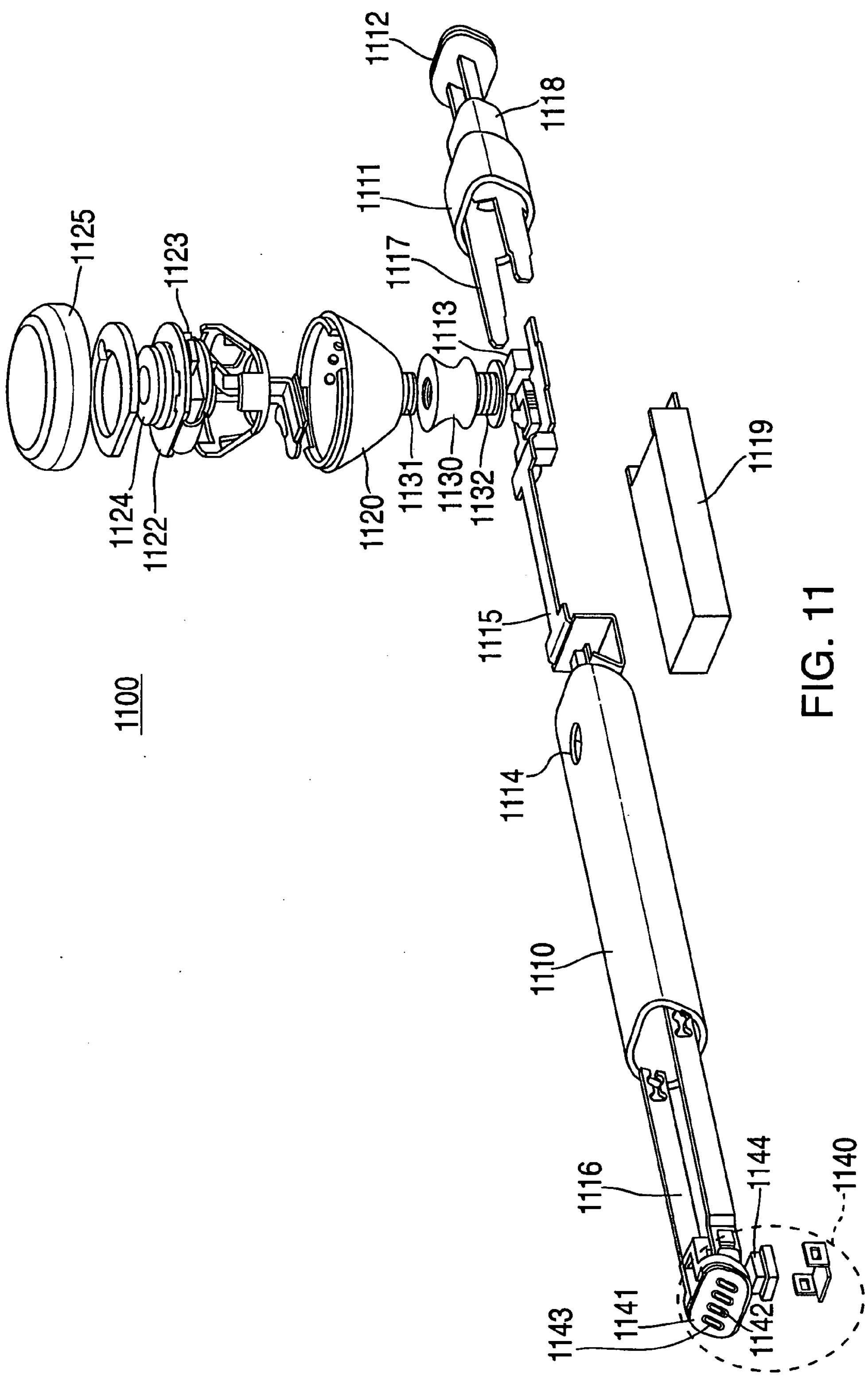

1100
1125
1123
1124
1122
1120
1131
1130
1132
1113
1117
1111
1118
1112
1119
1115
1114
1110
1116
1144
1140
1143
1141
1142

FIG. 11

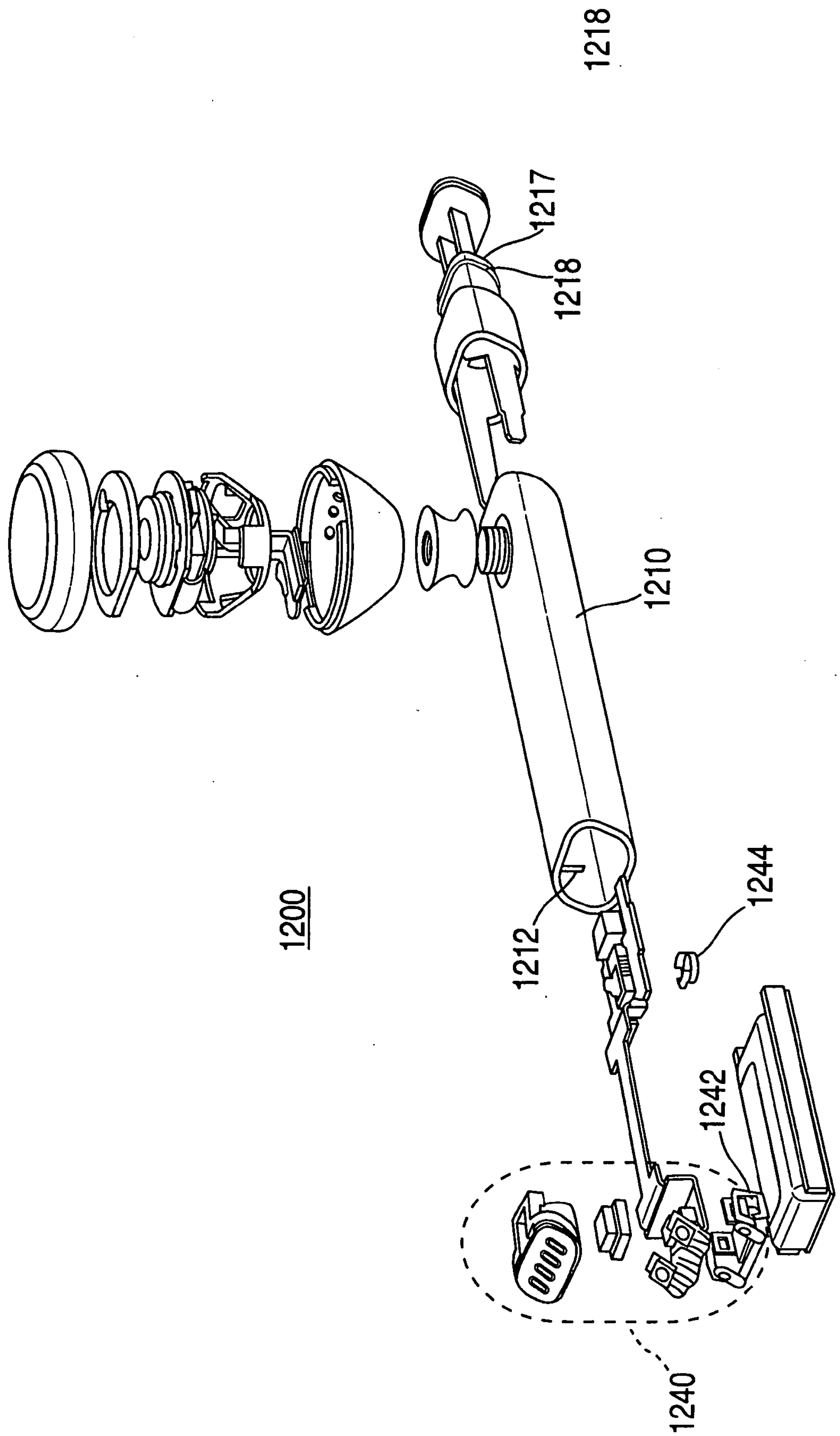


FIG. 12

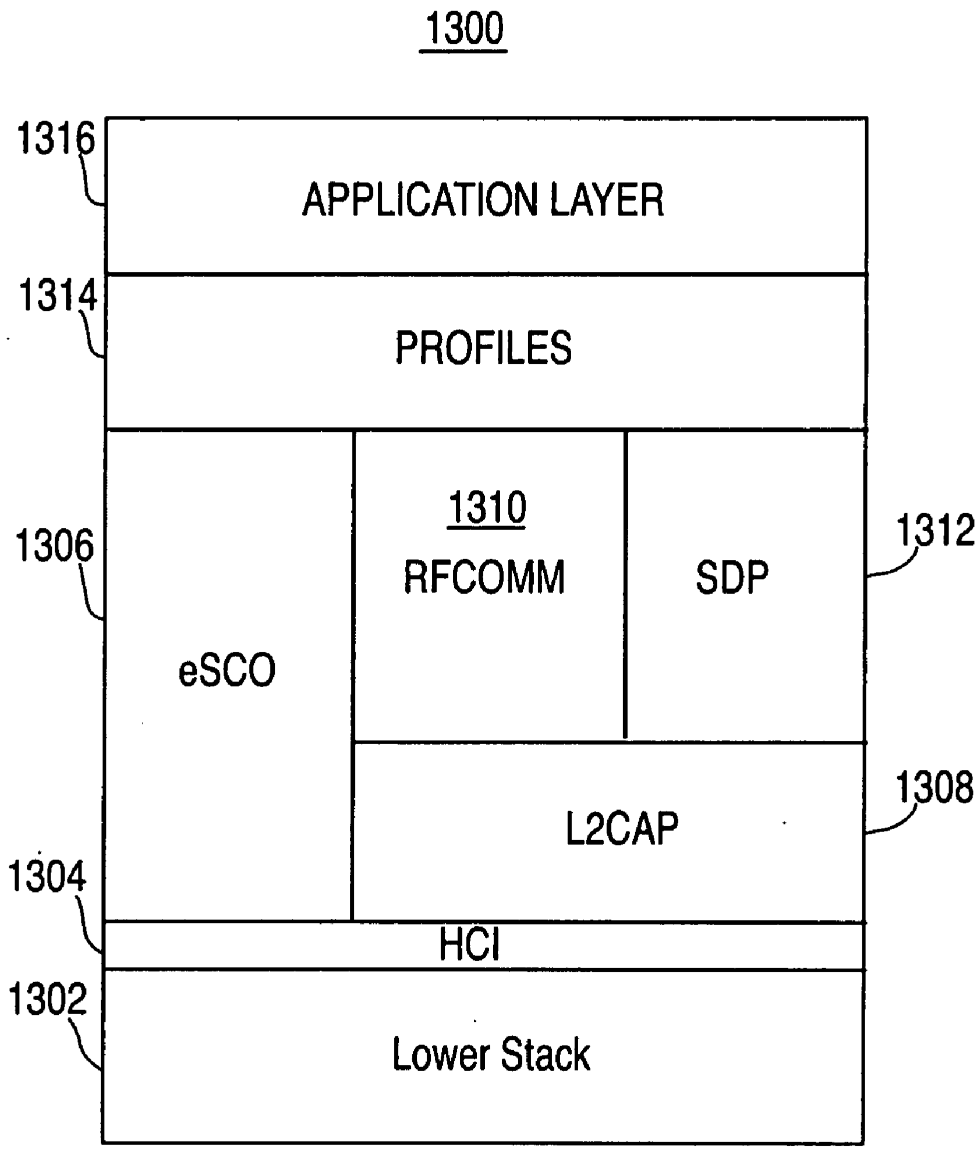

1300
1316
APPLICATION LAYER
1314
PROFILES
1306
eSCO
1310
RFCOMM
SDP
1312
L2CAP
1308
1304
HCI
1302
Lower Stack

FIG. 13

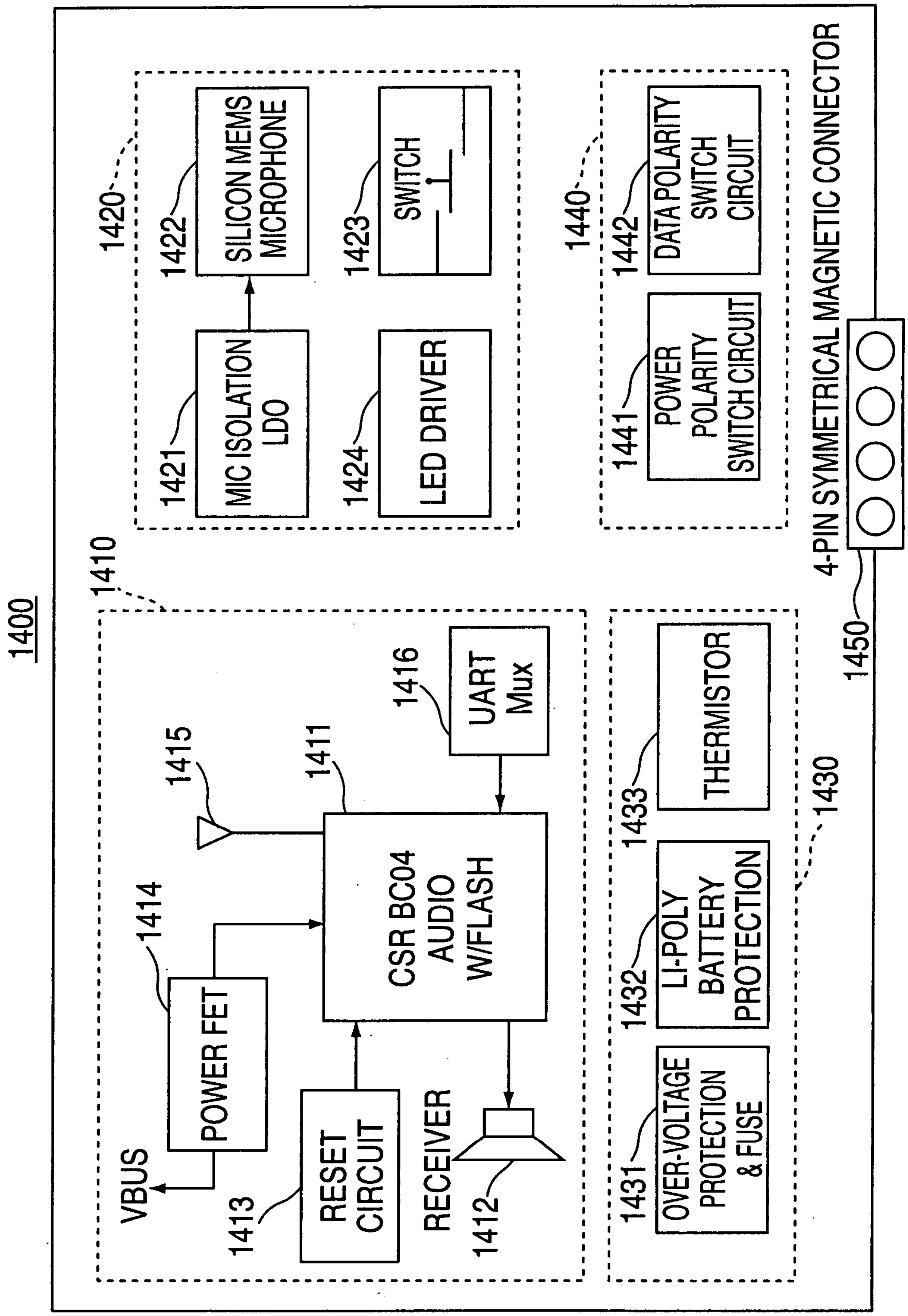

1400
1410
VBUS
POWER FET
1414
RESET CIRCUIT
1413
CSR BC04 AUDIO W/FLASH
1411
1415
UART Mux
1416
RECEIVER
1412
1420
MIC ISOLATION LDO
1421
SILICON MEMS MICROPHONE
1422
LED DRIVER
1424
SWITCH
1423
1430
OVER-VOLTAGE PROTECTION & FUSE
1431
LI-POLY BATTERY PROTECTION
1432
THERMISTOR
1433
1440
POWER POLARITY SWITCH CIRCUIT
1441
DATA POLARITY SWITCH CIRCUIT
1442
4-PIN SYMMETRICAL MAGNETIC CONNECTOR
1450

FIG. 14

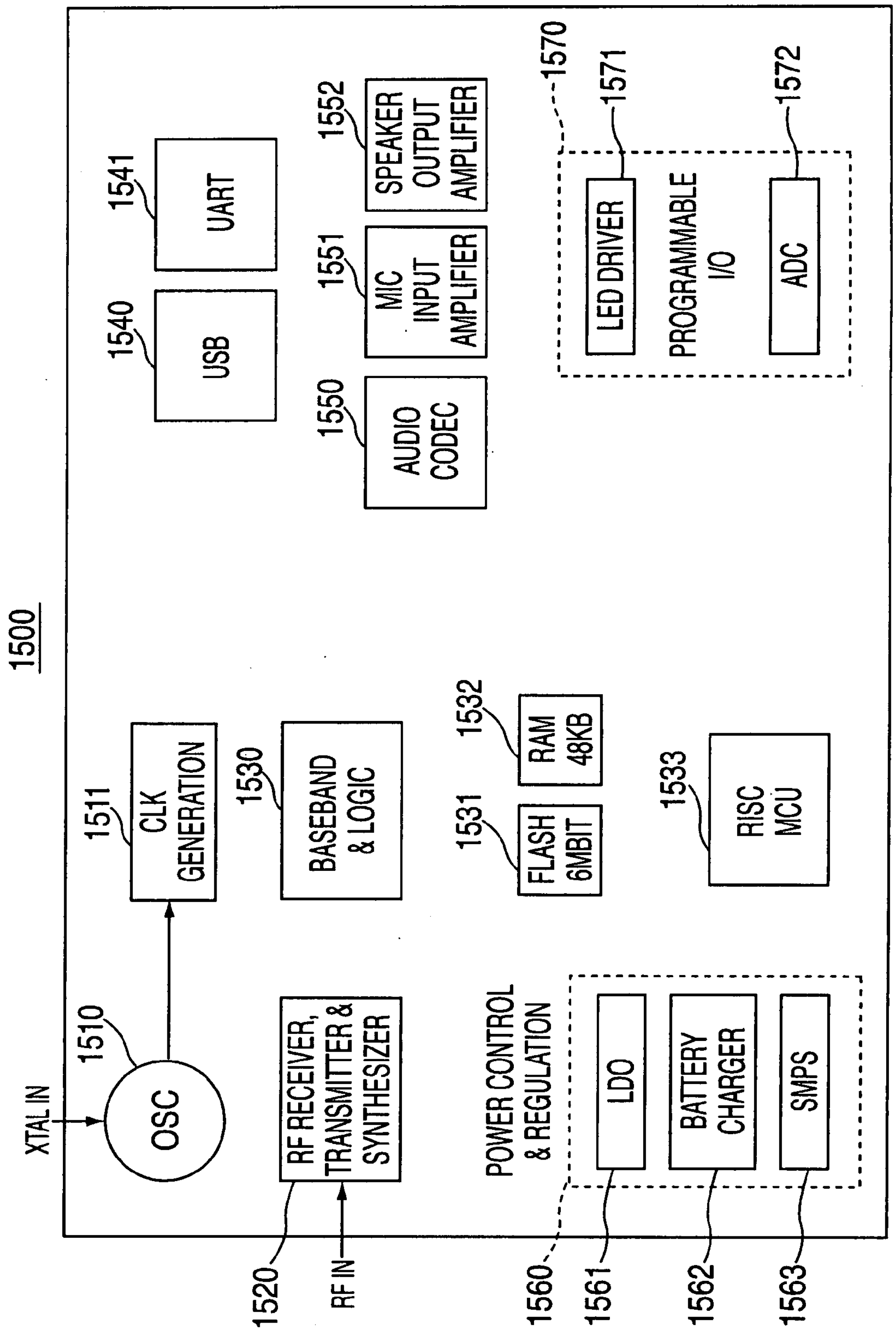

1500
XTAL IN
OSC
1510
CLK GENERATION
1511
RF RECEIVER, TRANSMITTER & SYNTHESIZER
1520
RF IN
BASEBAND & LOGIC
1530
FLASH 6MBIT
1531
RAM 48KB
1532
RISC MCU
1533
POWER CONTROL & REGULATION
1560
LDO
1561
BATTERY CHARGER
1562
SMPS
1563
USB
1540
UART
1541
AUDIO CODEC
1550
MIC INPUT AMPLIFIER
1551
SPEAKER OUTPUT AMPLIFIER
1552
PROGRAMMABLE I/O
1570
LED DRIVER
1571
ADC
1572

FIG. 15

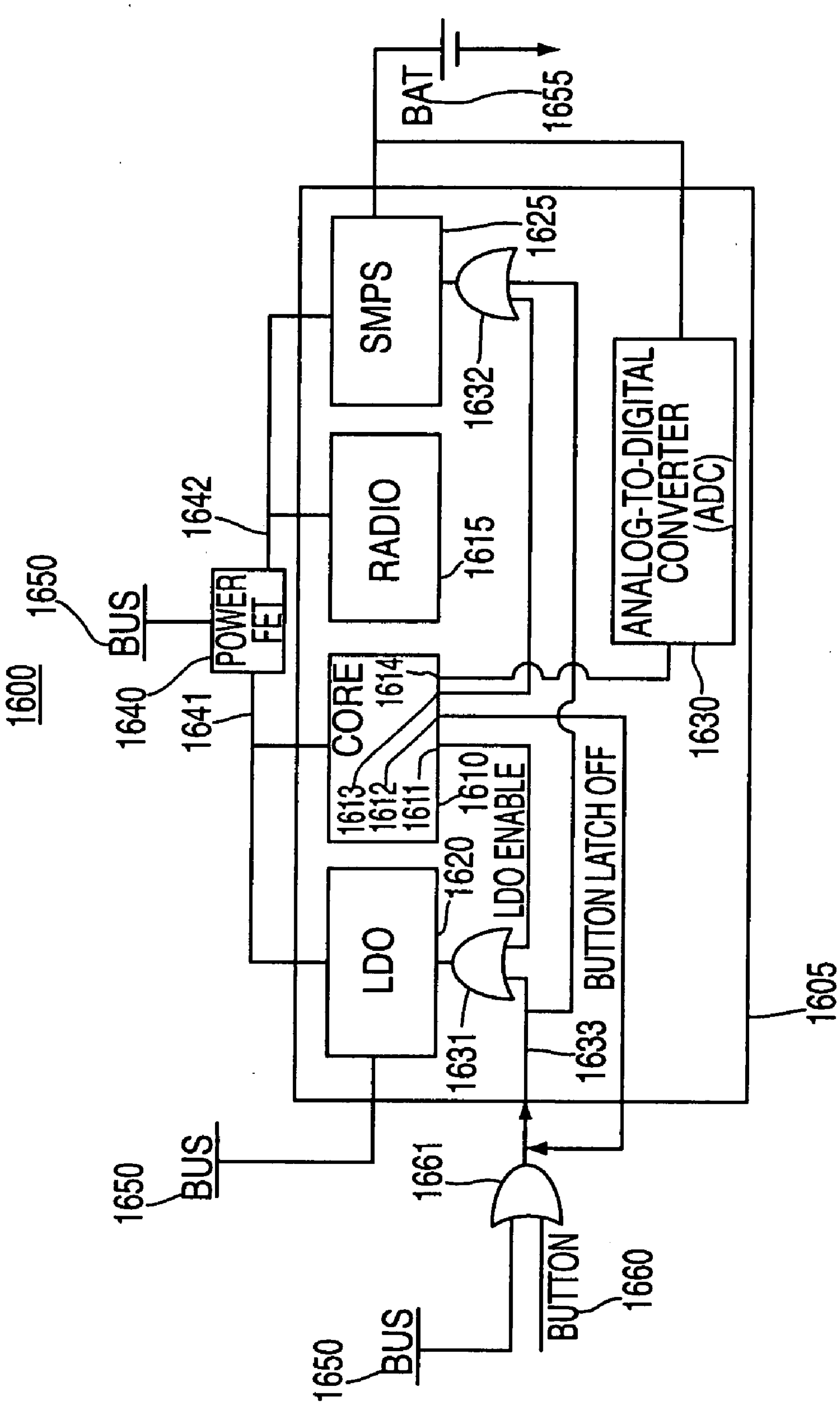

1600
BUS
1650
POWER FET
1640
1641
1642
RADIO
1615
SMPS
1625
1632
BAT
1655
CORE
1614
1613
1612
1611
1610
LDO ENABLE
1620
LDO
1631
1633
BUTTON LATCH OFF
ANALOG-TO-DIGITAL CONVERTER (ADC)
1630
1605
BUS
1650
1661
BUTTON
1660
BUS
1650

FIG. 16

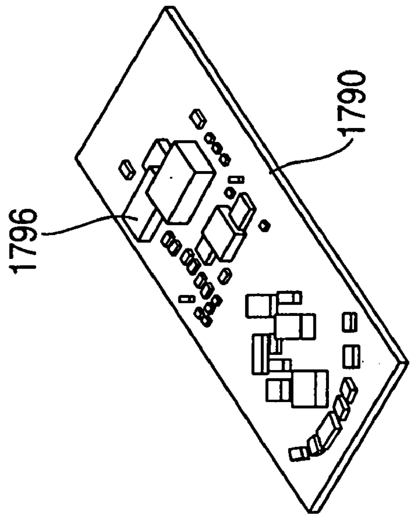


FIG. 17B
PRIOR ART

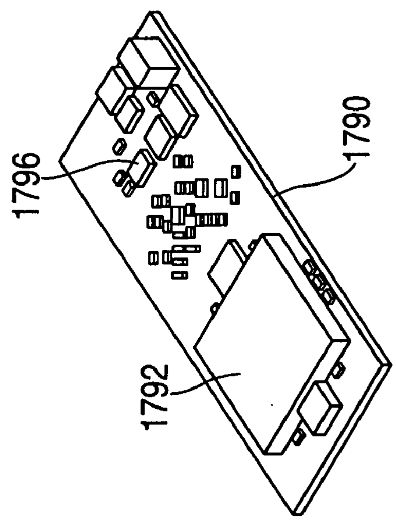


FIG. 17A
PRIOR ART

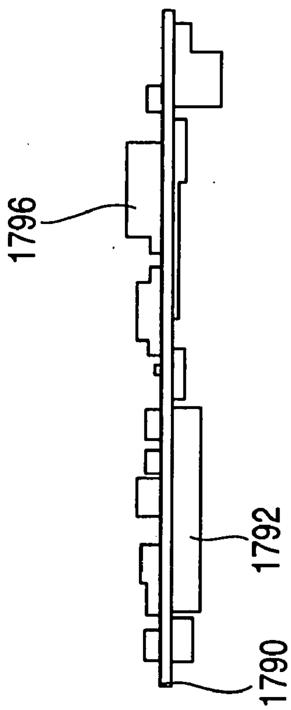


FIG. 17C
PRIOR ART

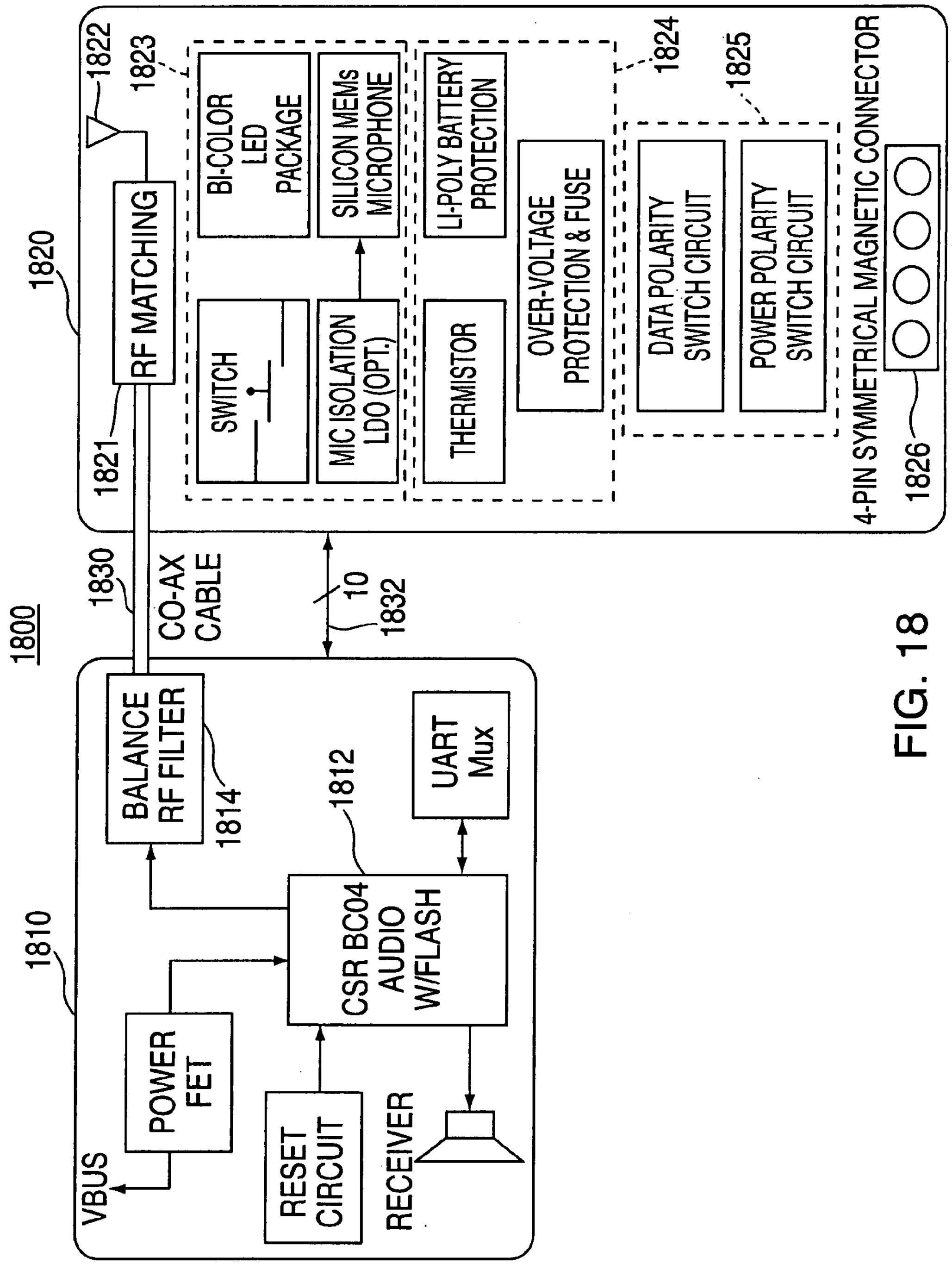

1800
1810
VBUS
POWER FET
RESET CIRCUIT
RECEIVER
CSR BC04 AUDIO W/FLASH
1812
UART Mux
BALANCE RF FILTER
1814
1830
CO-AX CABLE
10
1832
1820
RF MATCHING
1821
1822
1823
BI-COLOR LED PACKAGE
SILICON MEMs MICROPHONE
SWITCH
MIC ISOLATION LDO (OPT.)
1824
LI-POLY BATTERY PROTECTION
THERMISTOR
OVER-VOLTAGE PROTECTION & FUSE
1825
DATA POLARITY SWITCH CIRCUIT
POWER POLARITY SWITCH CIRCUIT
4-PIN SYMMETRICAL MAGNETIC CONNECTOR
1826

FIG. 18

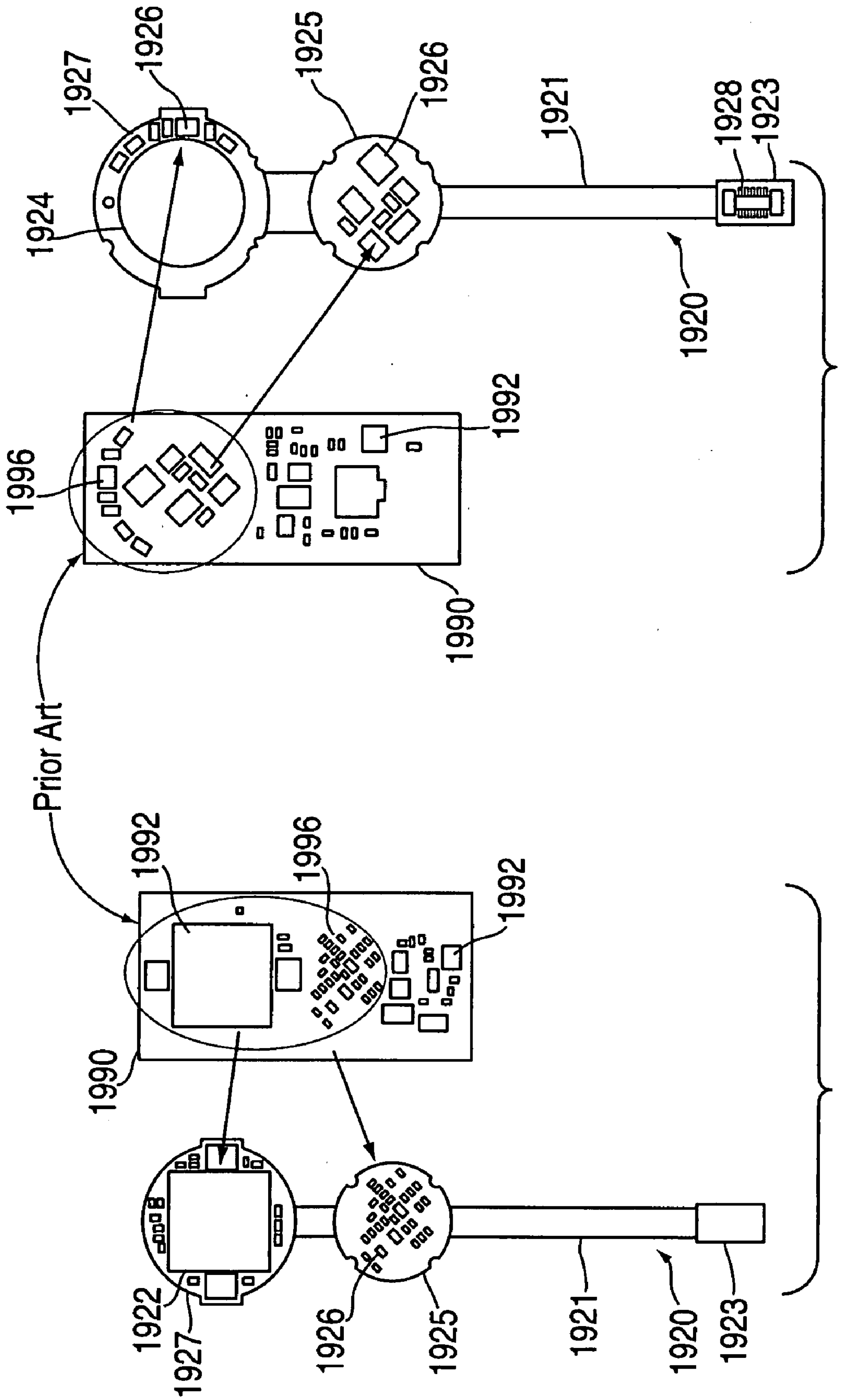


FIG. 19B

FIG. 19A

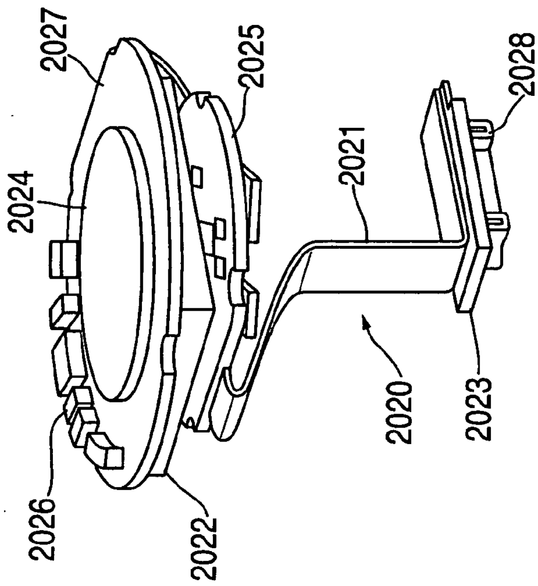


FIG. 20B

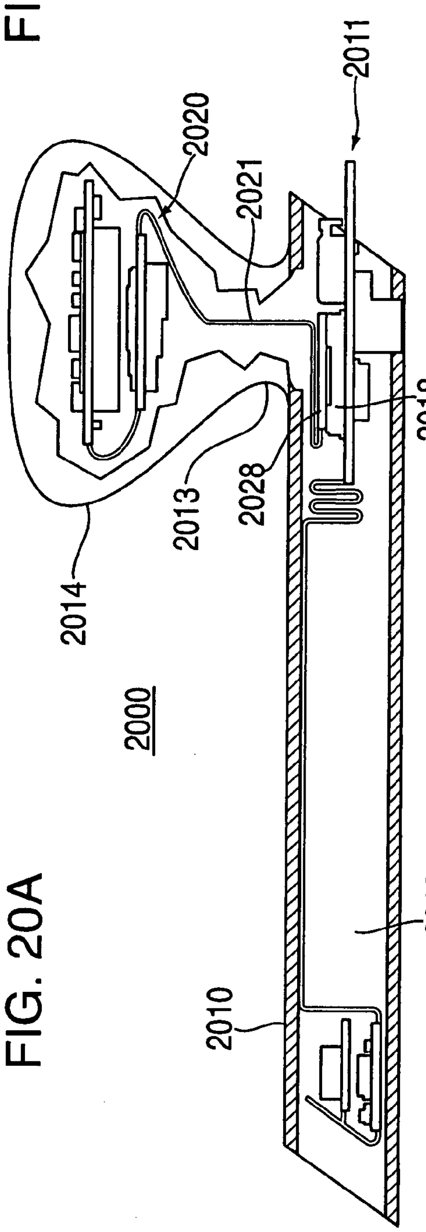


FIG. 20C

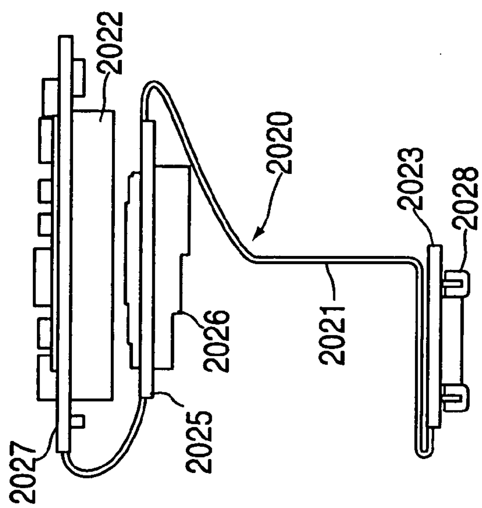


FIG. 20A

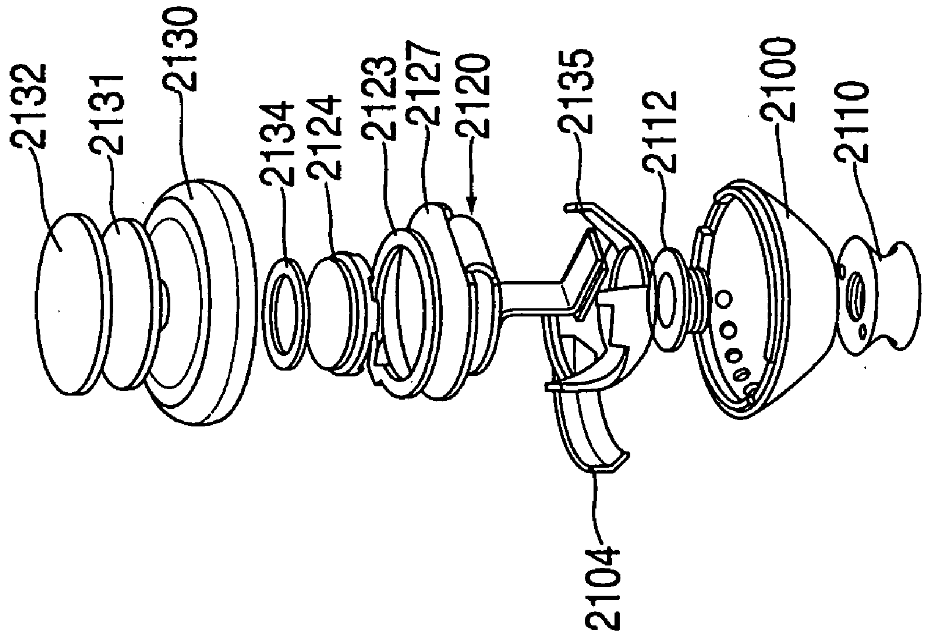


FIG. 21B

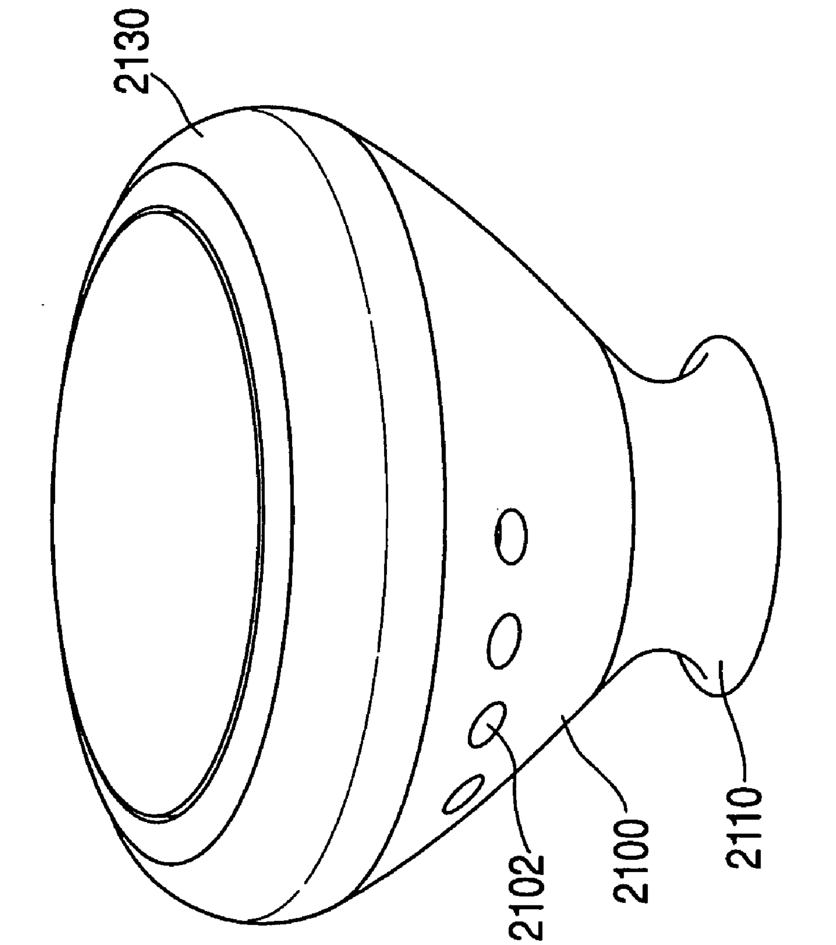


FIG. 21A

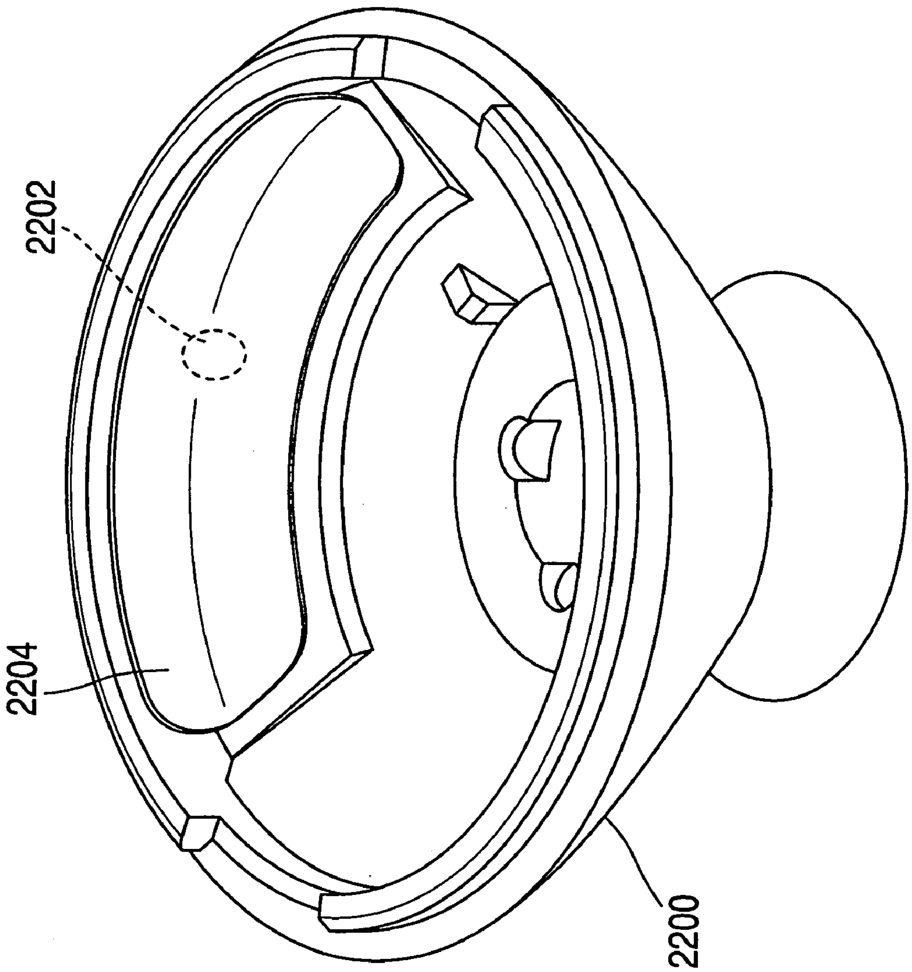


FIG. 22

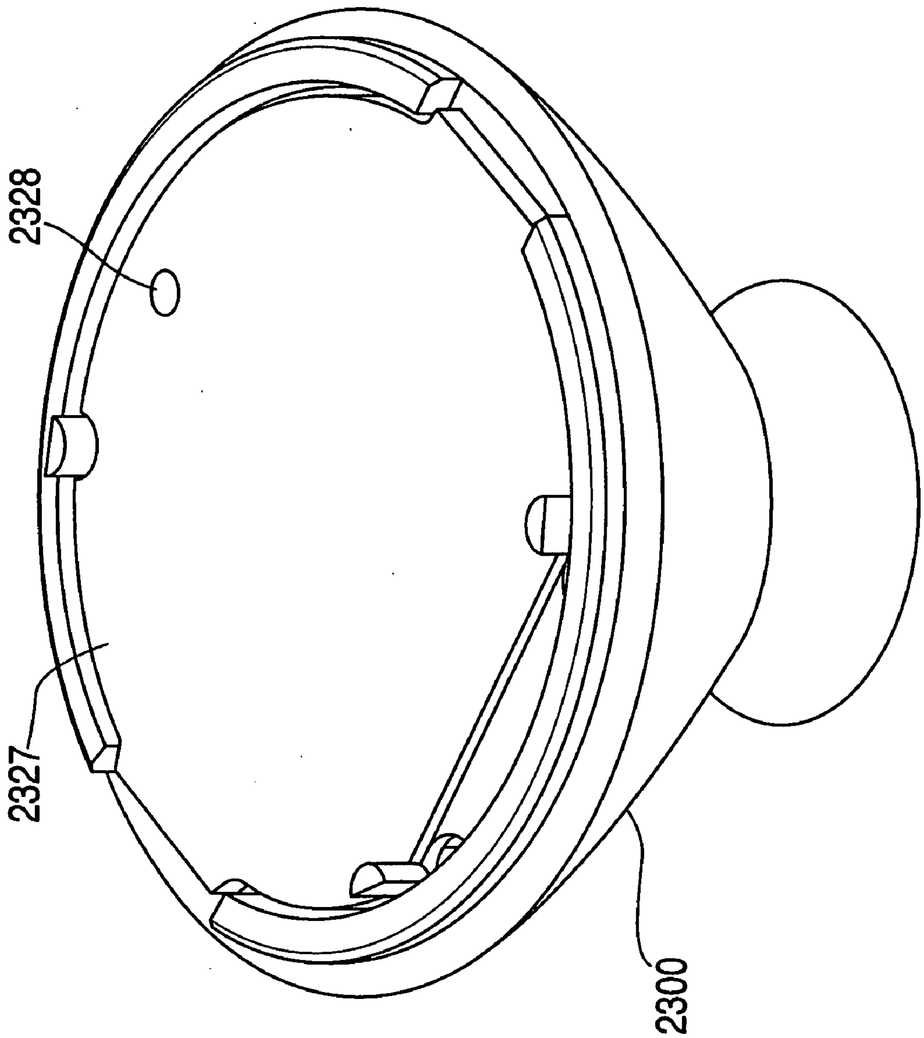


FIG. 23

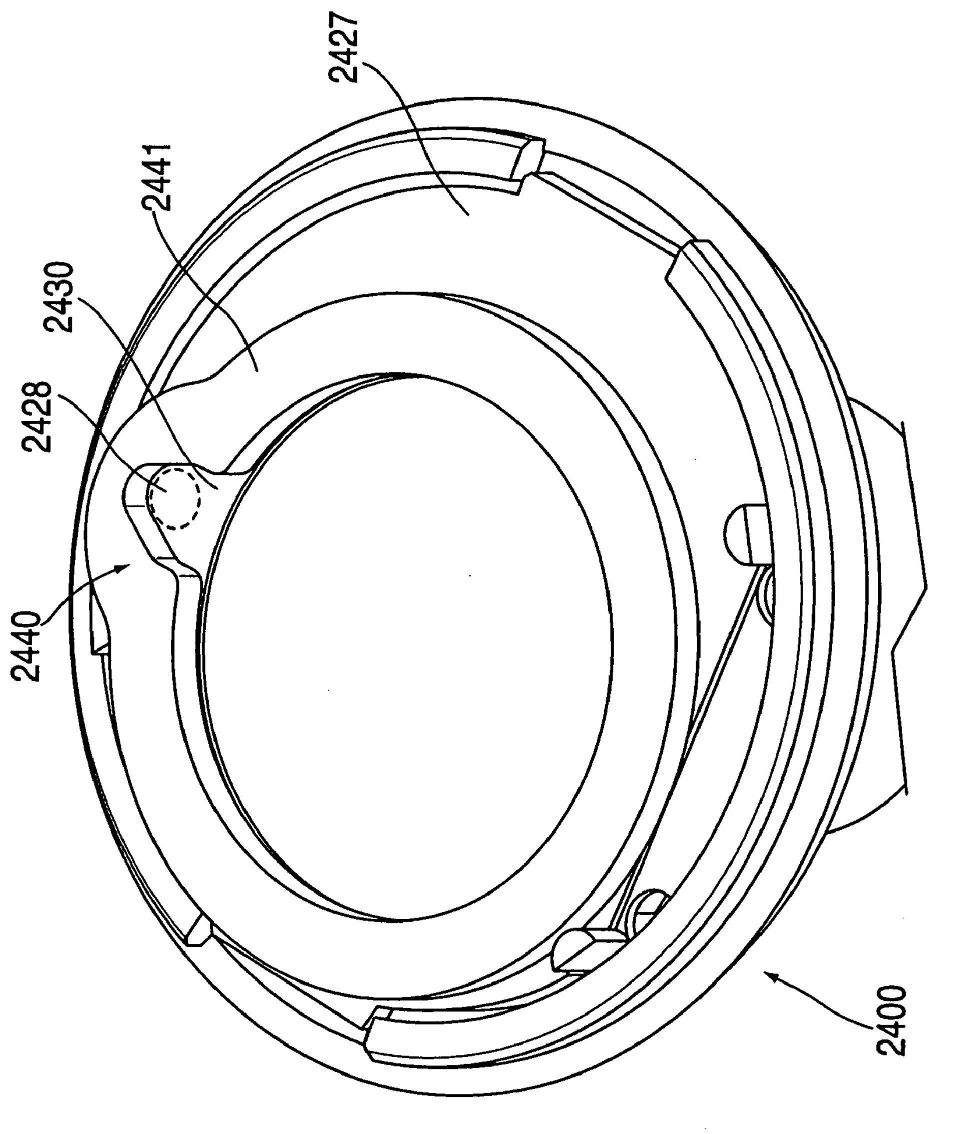


FIG. 24

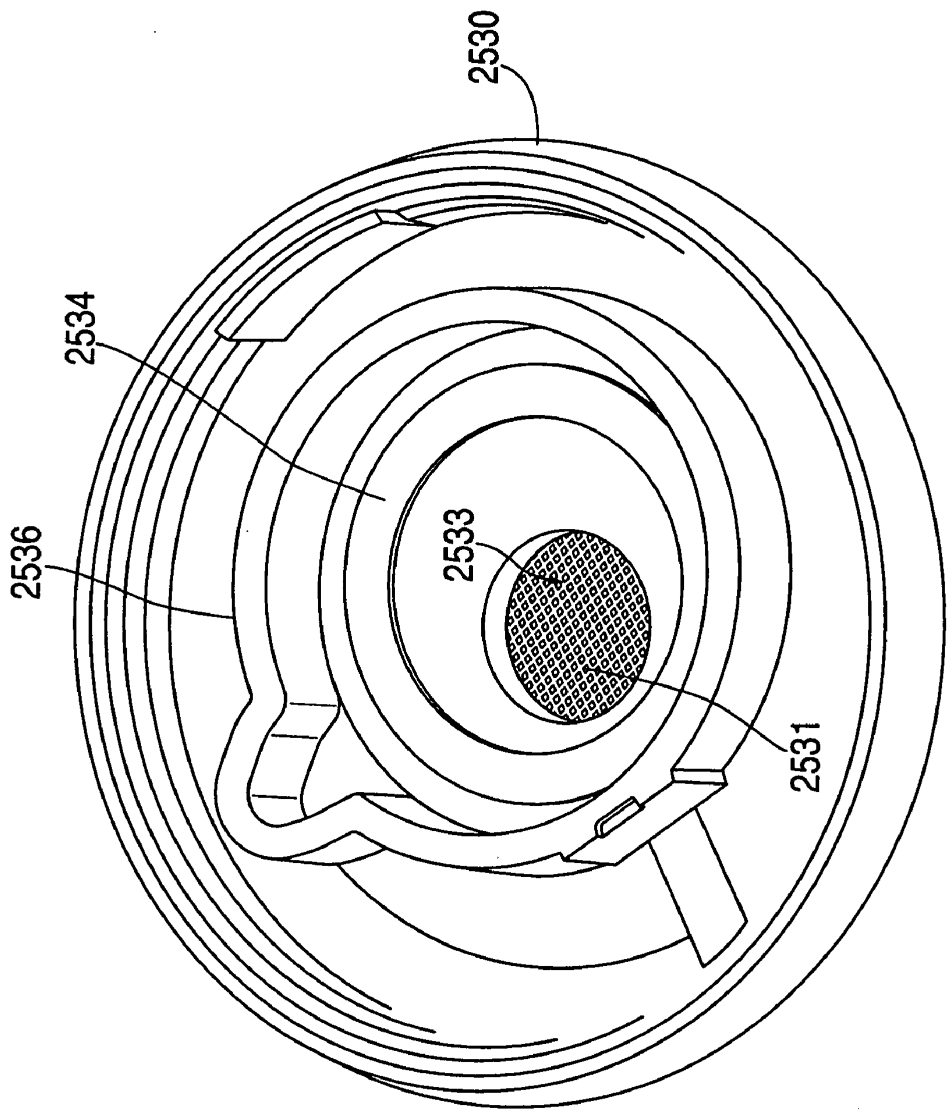


FIG. 25

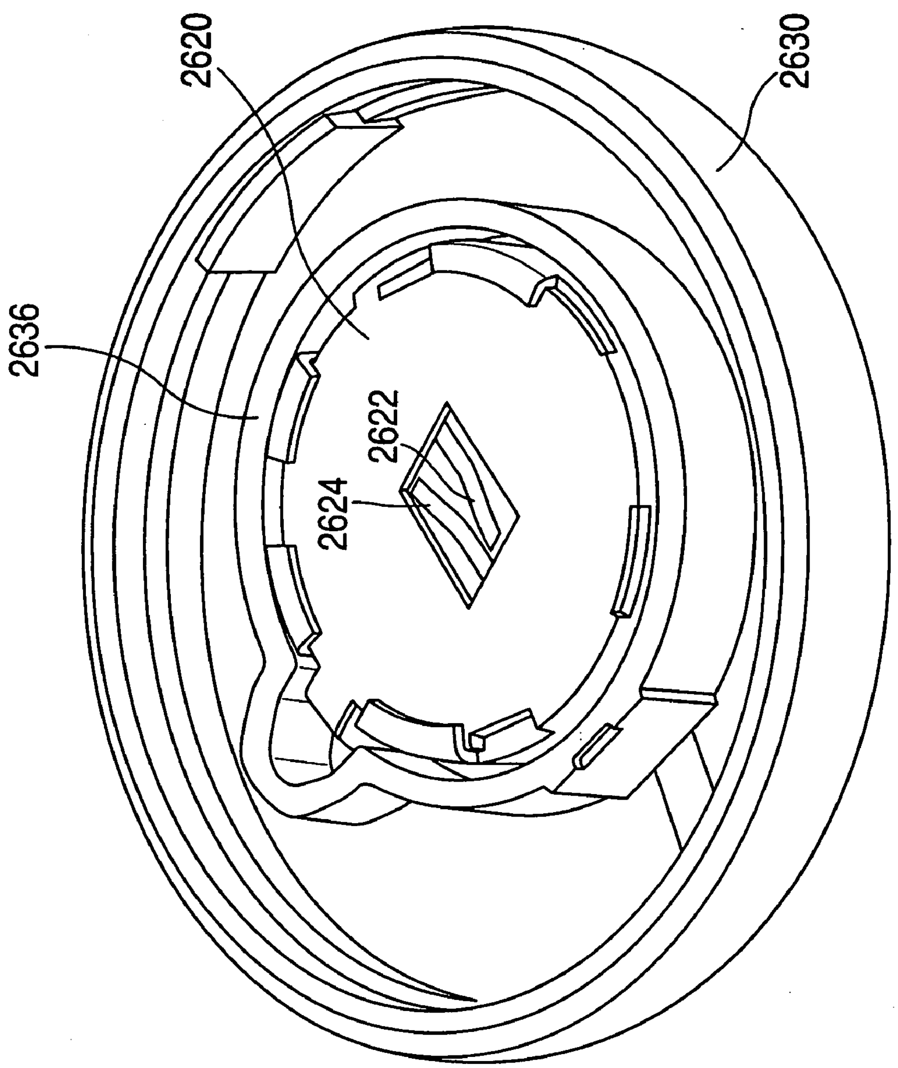


FIG. 26A

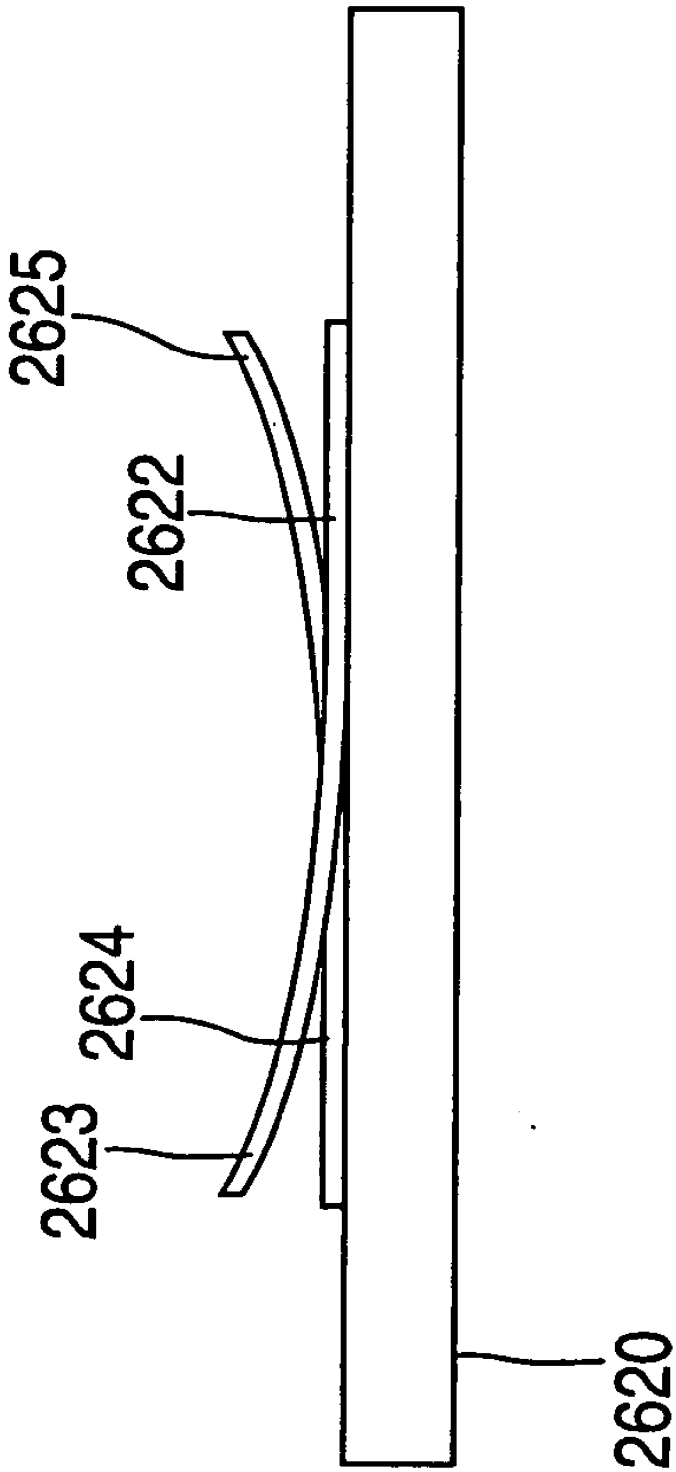


FIG. 26B

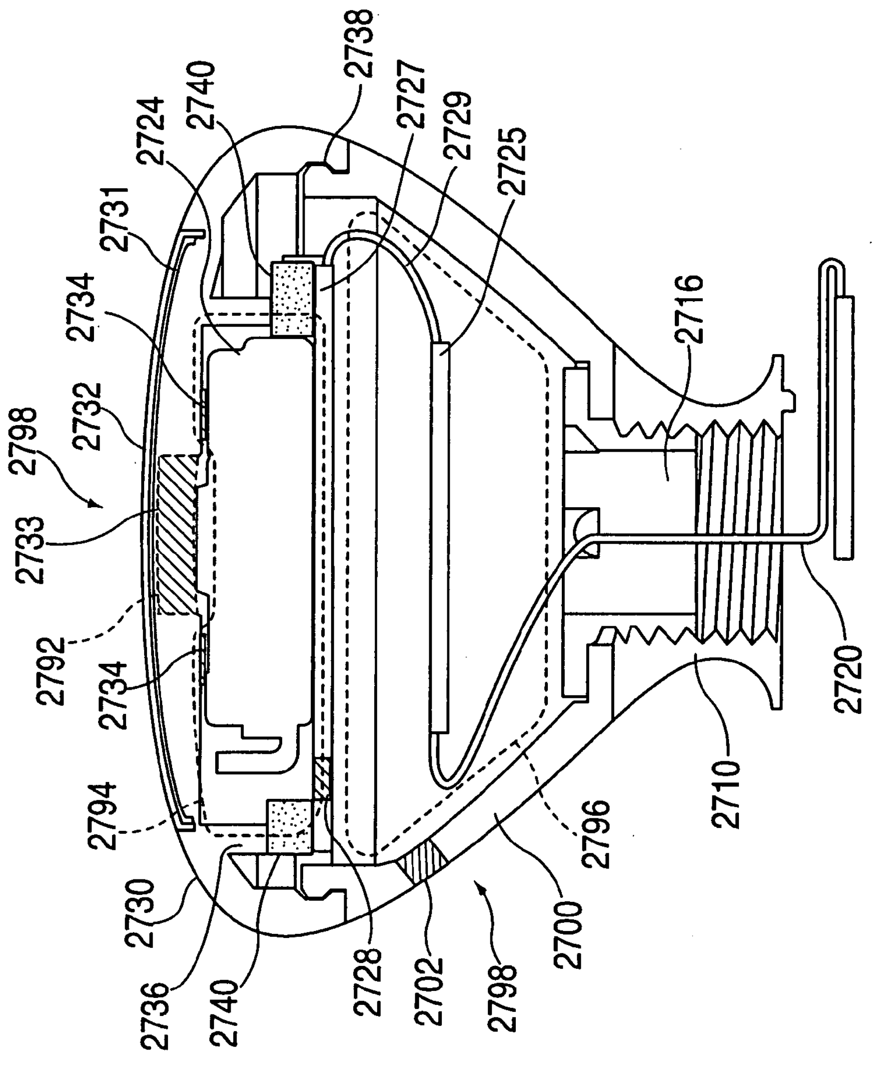

2738
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FIG. 27A

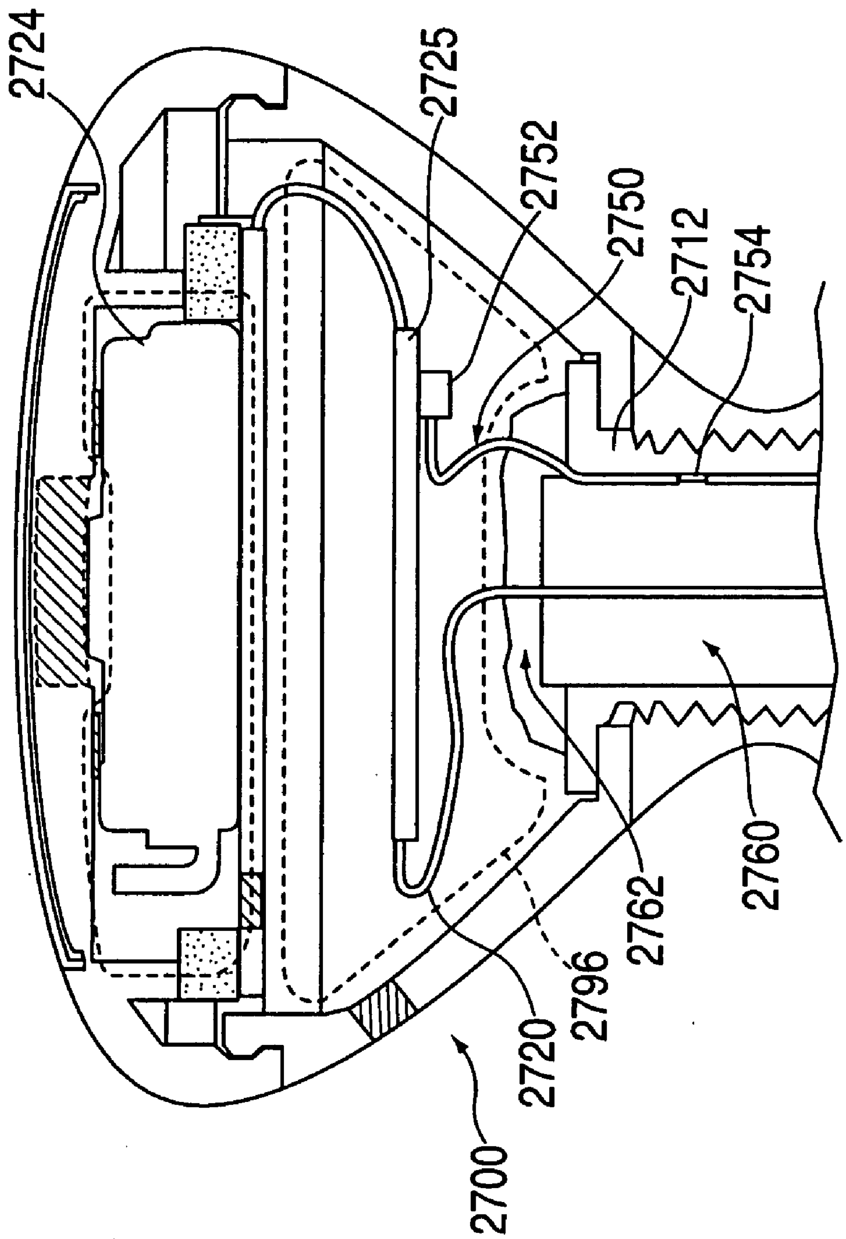


FIG. 27B

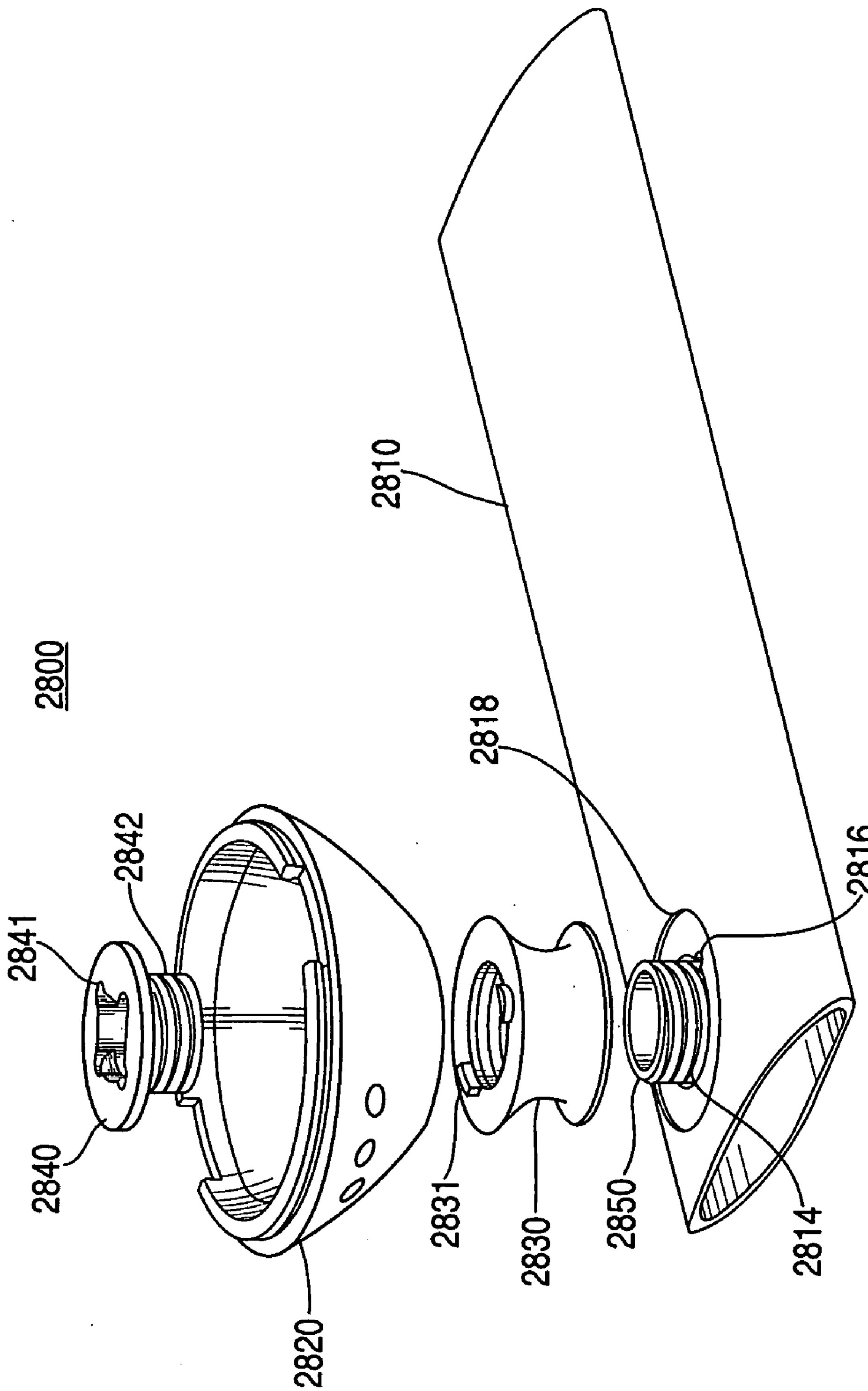


FIG. 28

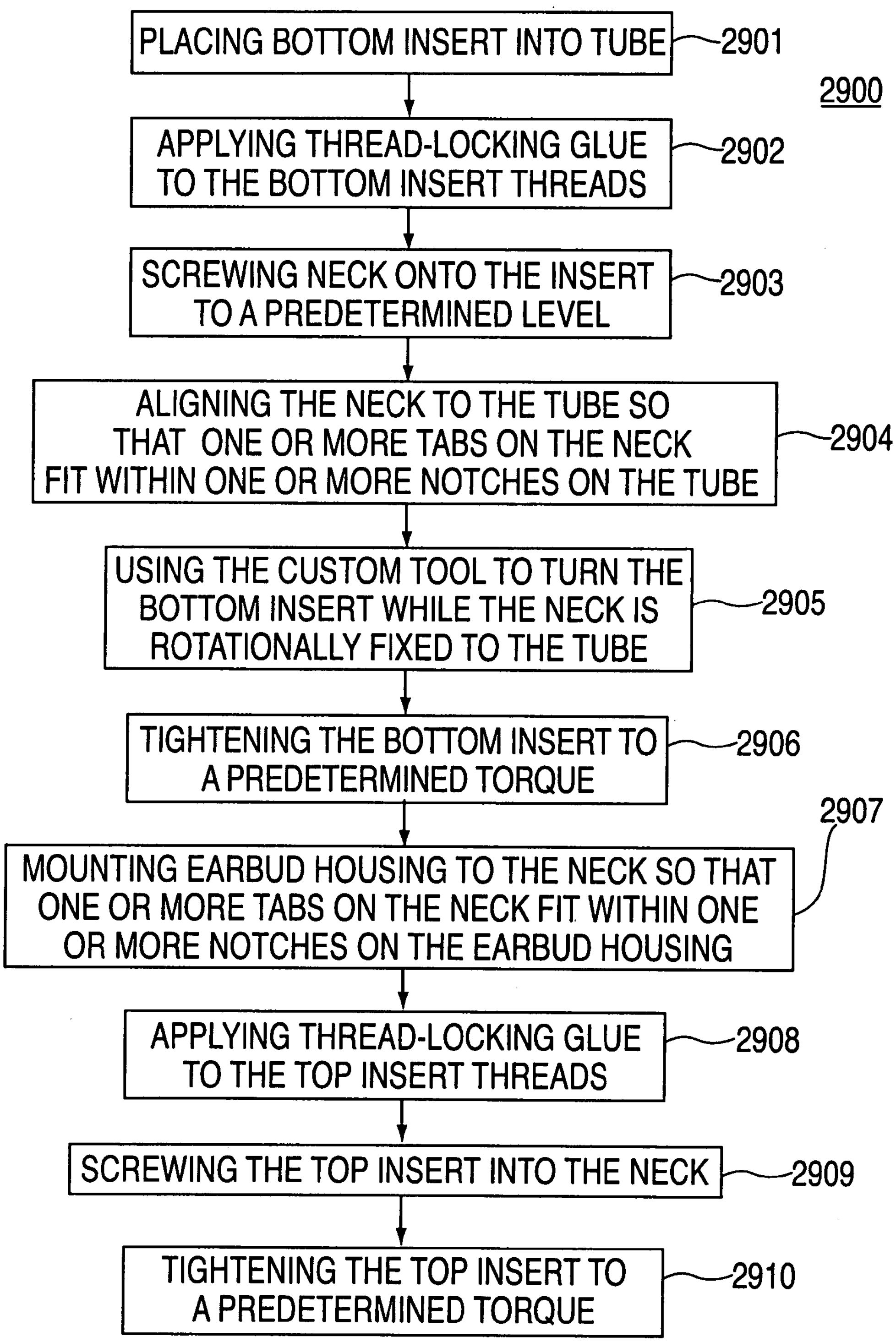

PLACING BOTTOM INSERT INTO TUBE
2901
2900
APPLYING THREAD-LOCKING GLUE TO THE BOTTOM INSERT THREADS
2902
SCREWING NECK ONTO THE INSERT TO A PREDETERMINED LEVEL
2903
ALIGNING THE NECK TO THE TUBE SO THAT ONE OR MORE TABS ON THE NECK FIT WITHIN ONE OR MORE NOTCHES ON THE TUBE
2904
USING THE CUSTOM TOOL TO TURN THE BOTTOM INSERT WHILE THE NECK IS ROTATIONALLY FIXED TO THE TUBE
2905
TIGHTENING THE BOTTOM INSERT TO A PREDETERMINED TORQUE
2906
2907
MOUNTING EARBUD HOUSING TO THE NECK SO THAT ONE OR MORE TABS ON THE NECK FIT WITHIN ONE OR MORE NOTCHES ON THE EARBUD HOUSING
APPLYING THREAD-LOCKING GLUE TO THE TOP INSERT THREADS
2908
SCREWING THE TOP INSERT INTO THE NECK
2909
TIGHTENING THE TOP INSERT TO A PREDETERMINED TORQUE
2910

FIG. 29

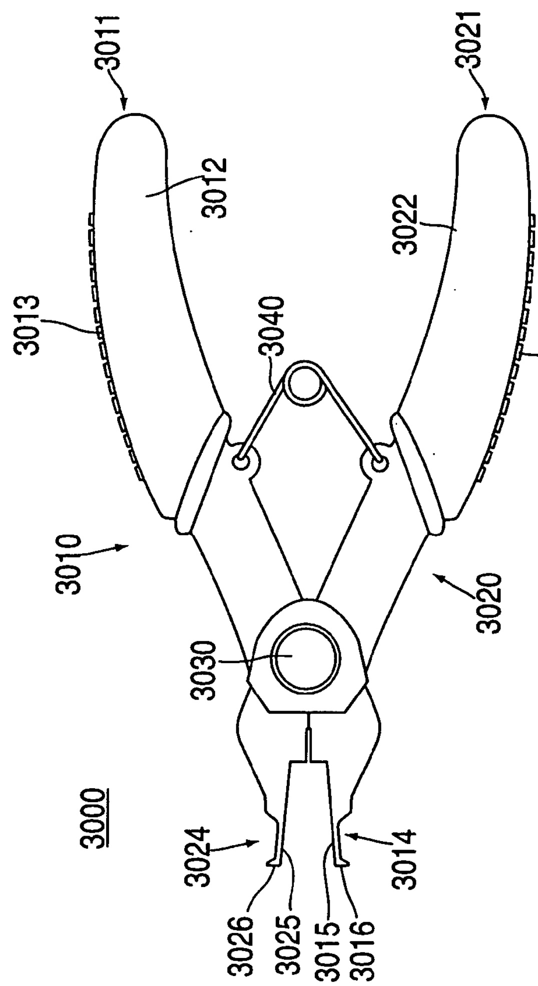


FIG. 30A

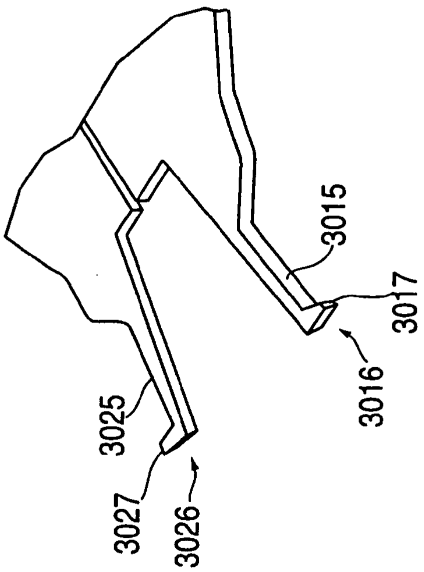


FIG. 30B

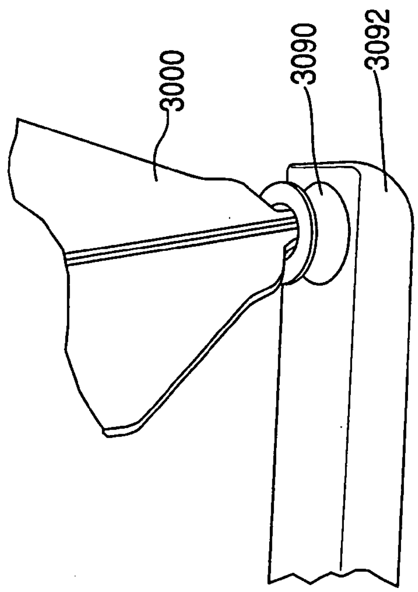


FIG. 30C

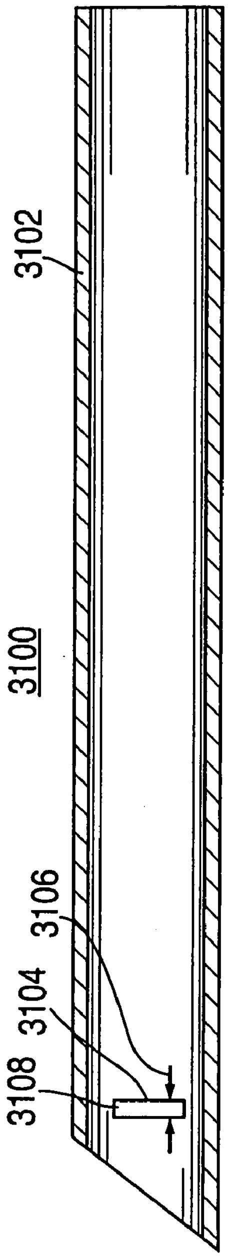


FIG. 31

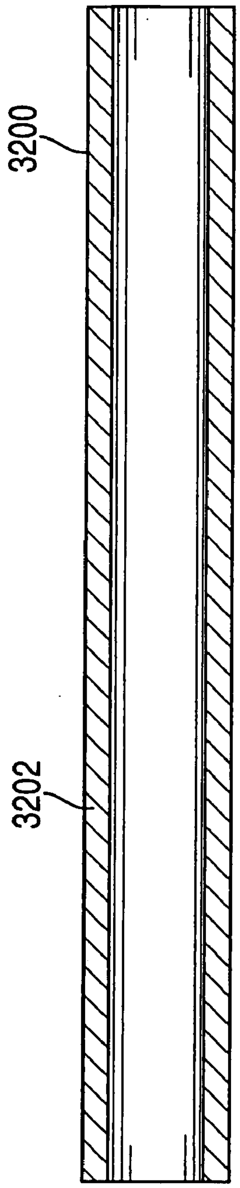


FIG. 32

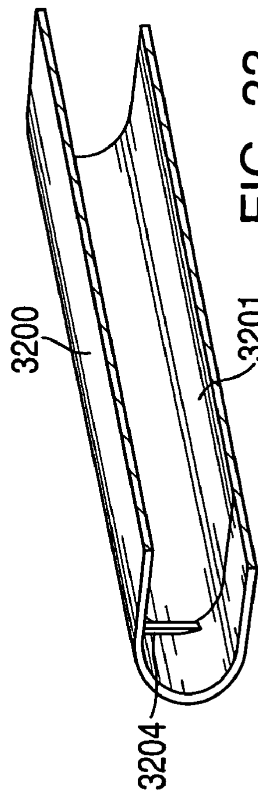


FIG. 33

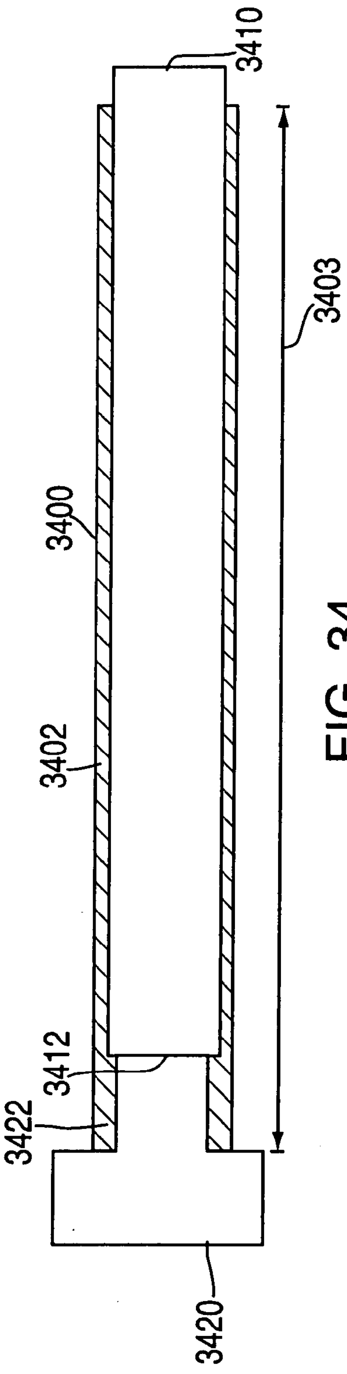


FIG. 34

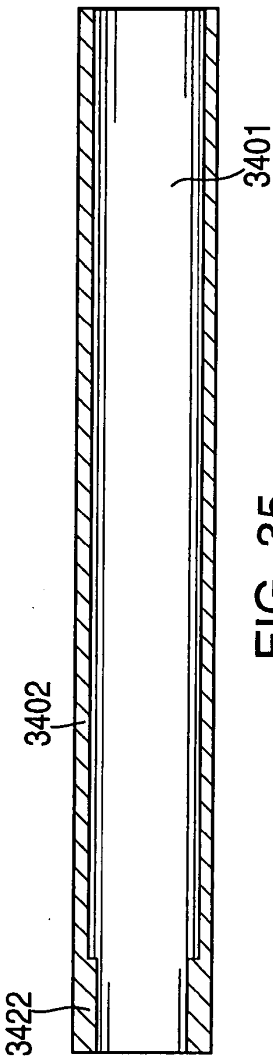


FIG. 35

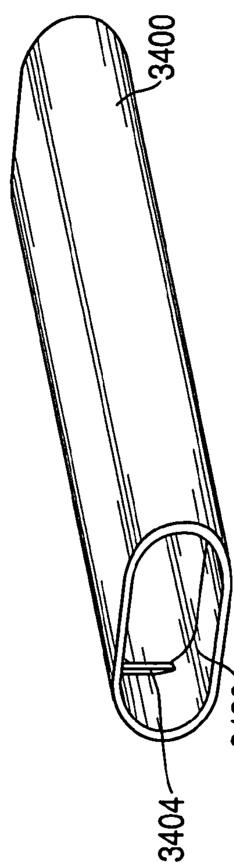


FIG. 36

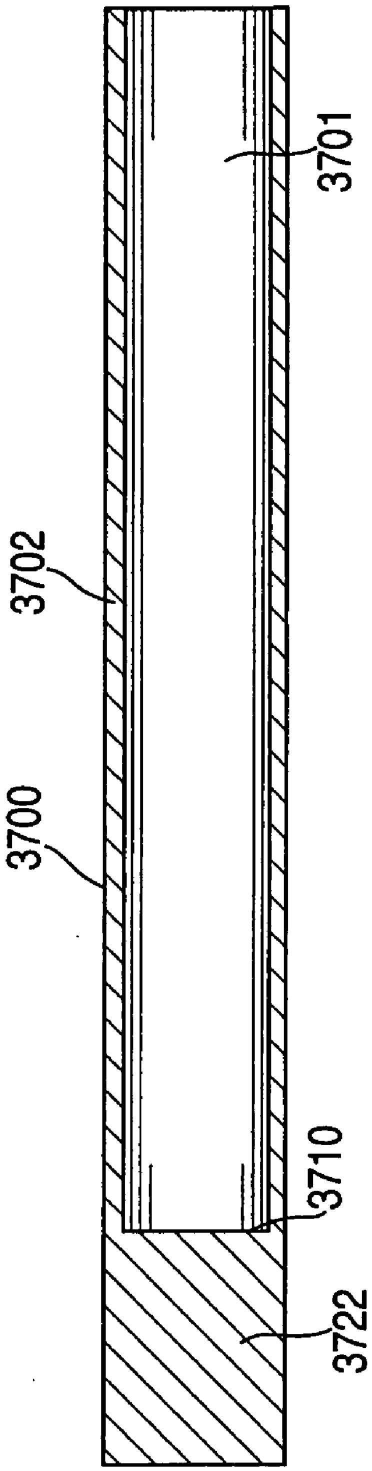


FIG. 37

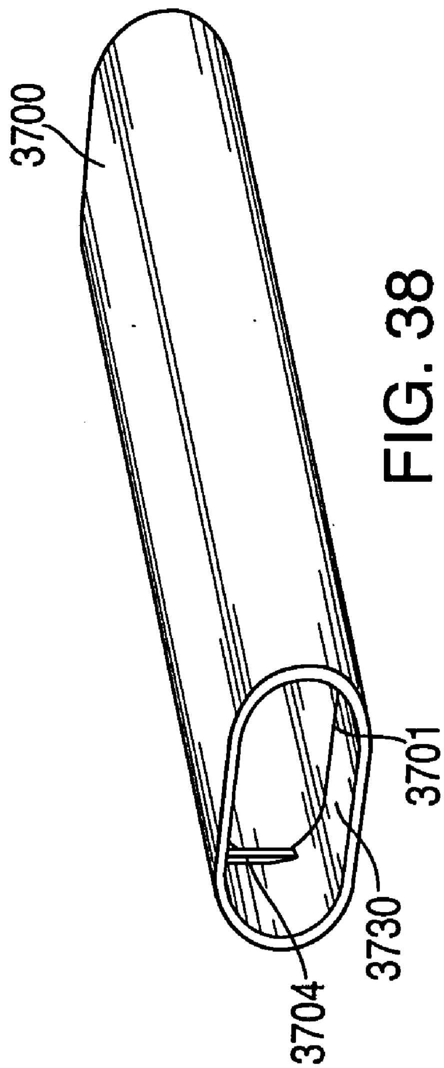
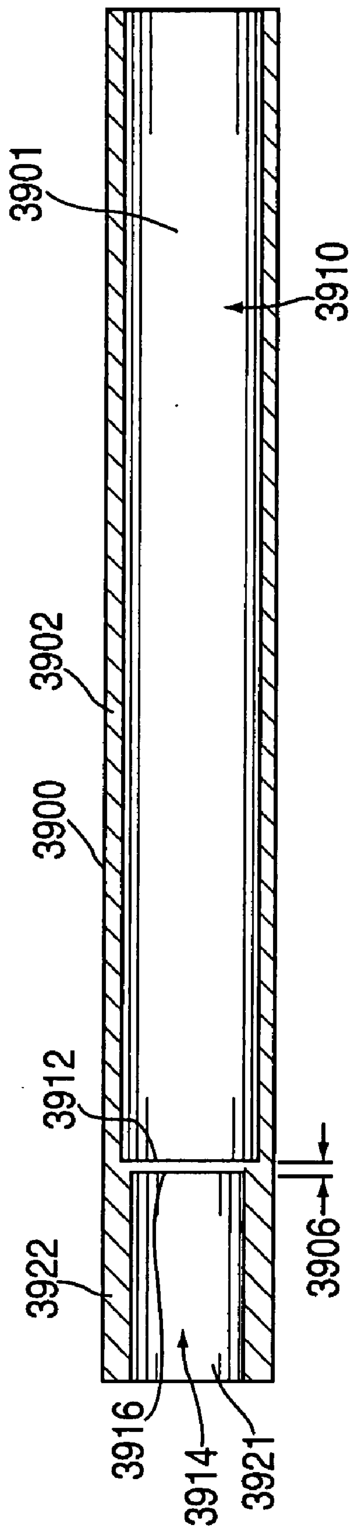


FIG. 38


3901
3910
3902
3900
3912
3922
3906
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3914
3921

FIG. 39

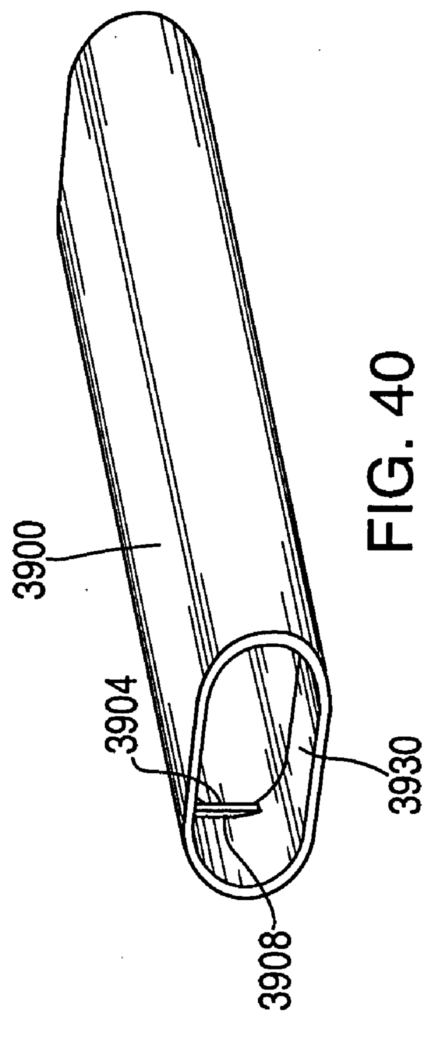

3900
3904
3930
3908

FIG. 40

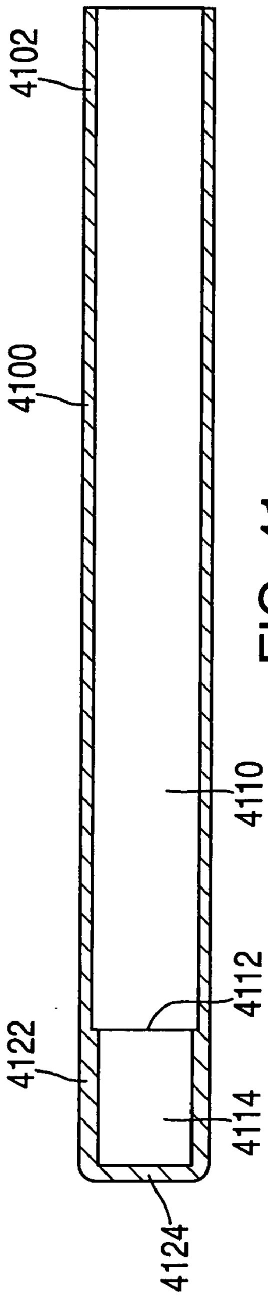


FIG. 41

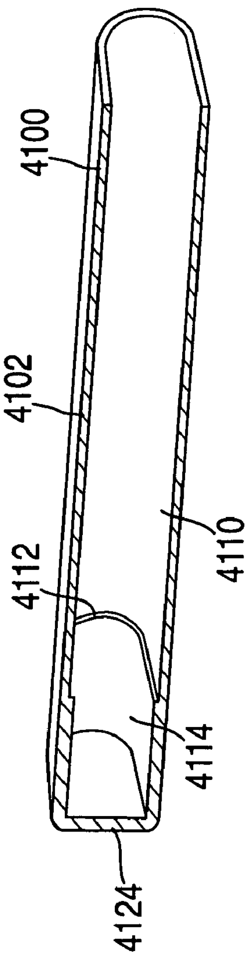


FIG. 42

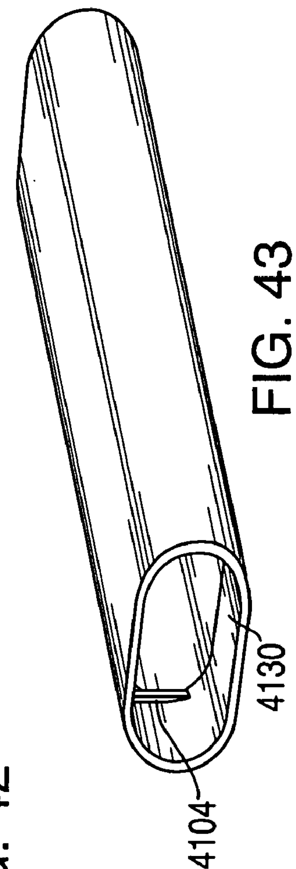


FIG. 43

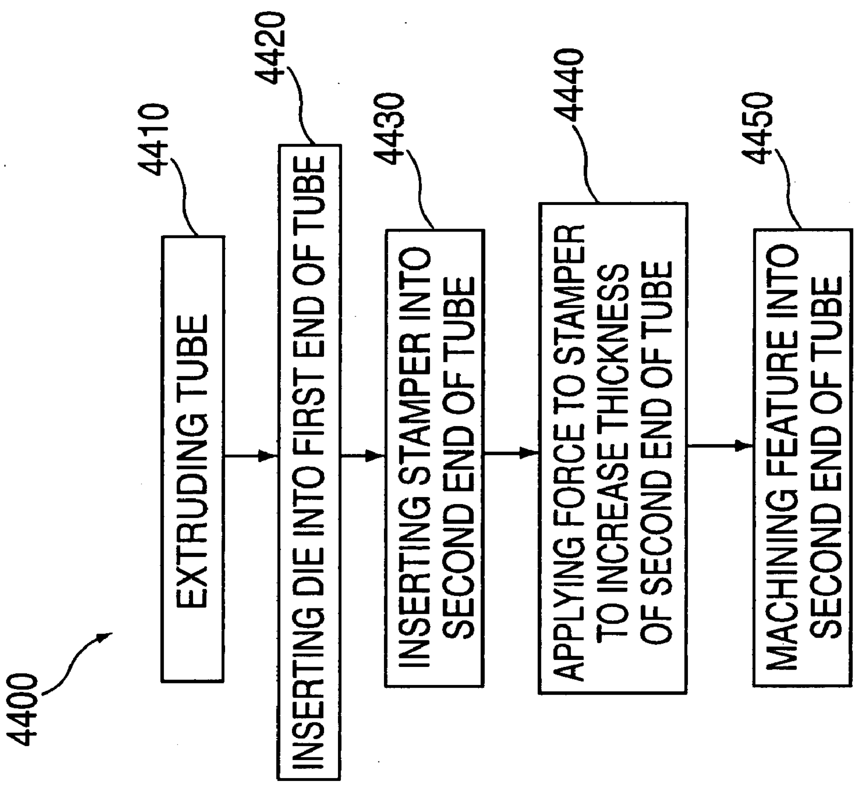

4400
EXTRUDING TUBE
4410
INSERTING DIE INTO FIRST END OF TUBE
4420
INSERTING STAMPER INTO SECOND END OF TUBE
4430
APPLYING FORCE TO STAMPER TO INCREASE THICKNESS OF SECOND END OF TUBE
4440
MACHINING FEATURE INTO SECOND END OF TUBE
4450

FIG. 44

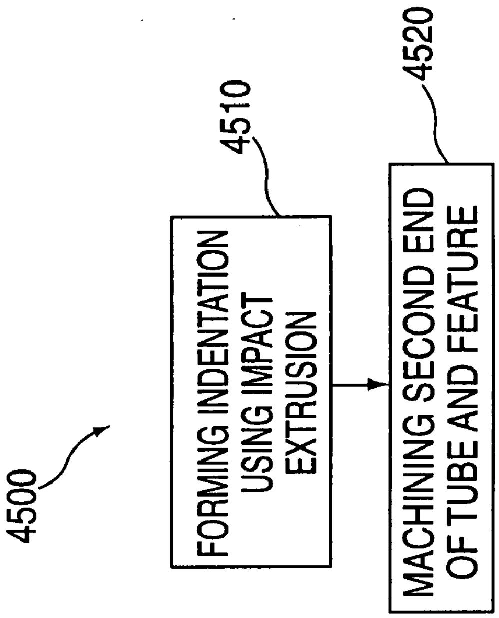

4500
FORMING INDENTATION USING IMPACT EXTRUSION
4510
MACHINING SECOND END OF TUBE AND FEATURE
4520

FIG. 45

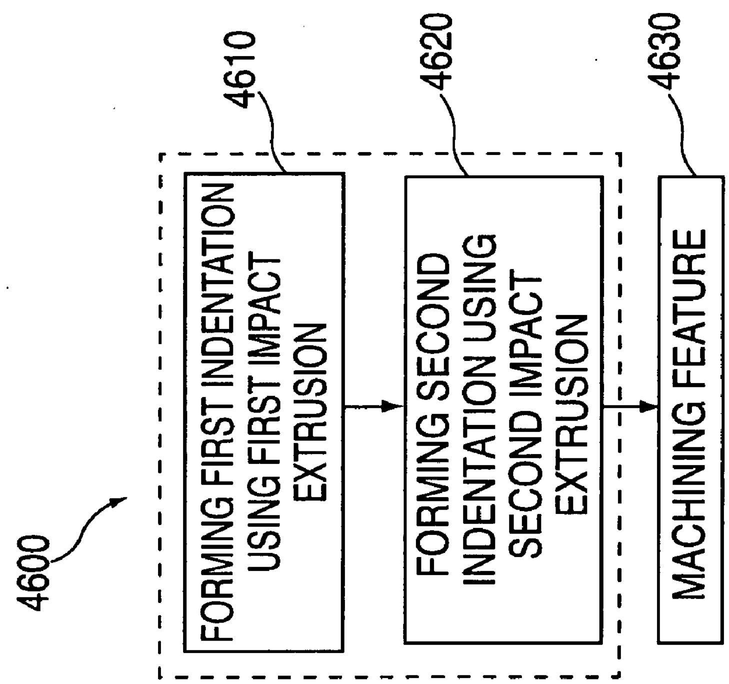

4600
FORMING FIRST INDENTATION USING FIRST IMPACT EXTRUSION
4610
FORMING SECOND INDENTATION USING SECOND IMPACT EXTRUSION
4620
MACHINING FEATURE
4630

FIG. 46

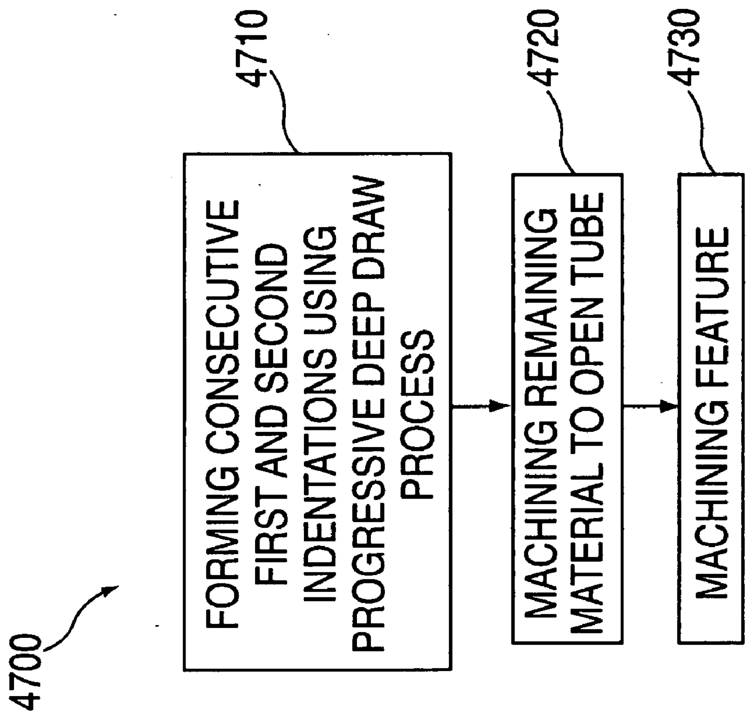

4700
FORMING CONSECUTIVE FIRST AND SECOND INDENTATIONS USING PROGRESSIVE DEEP DRAW PROCESS
4710
MACHINING REMAINING MATERIAL TO OPEN TUBE
4720
MACHINING FEATURE
4730

FIG. 47

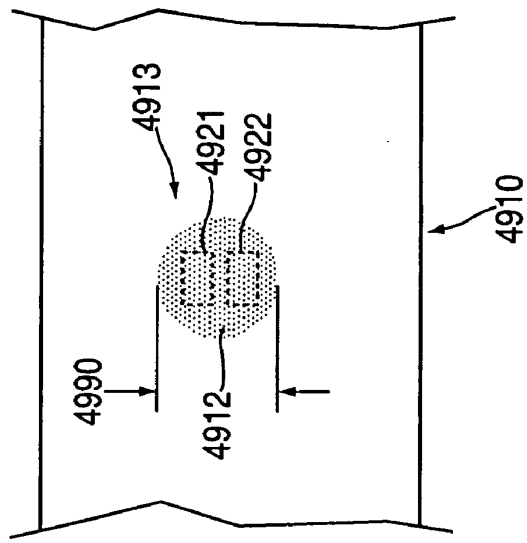

4913
4921
4922
4910
4990
4912

FIG. 49

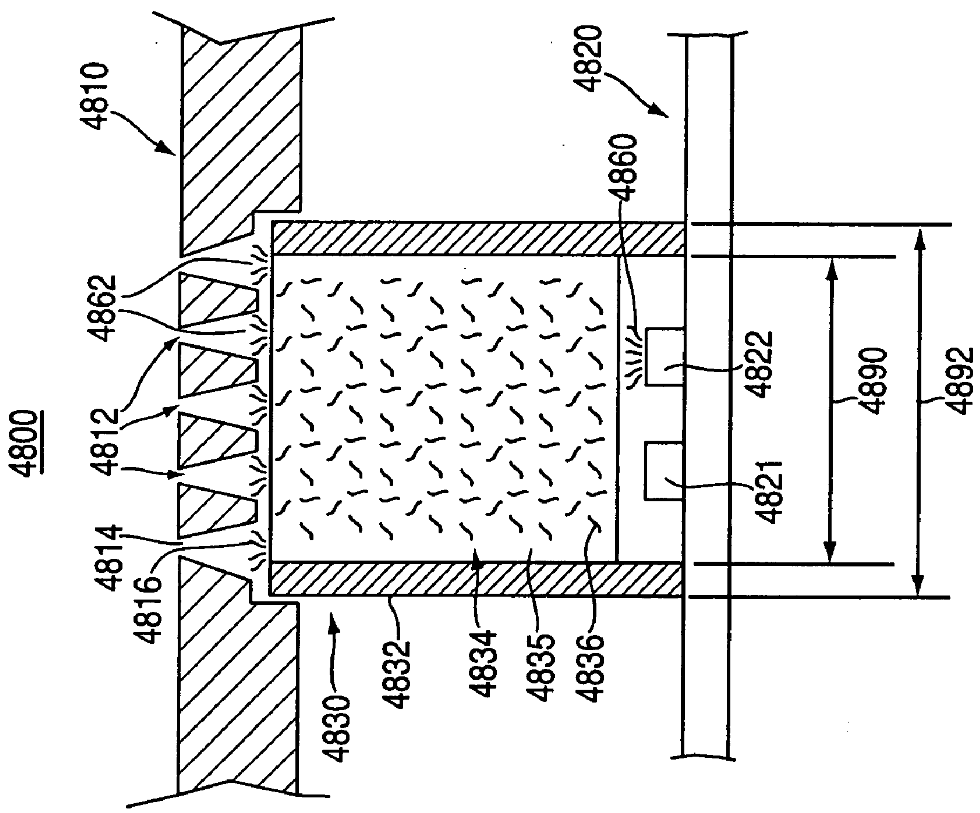

4800
4810
4820
4860
4862
4812
4814
4816
4822
4821
4890
4892
4830
4832
4834
4835
4836

FIG. 48

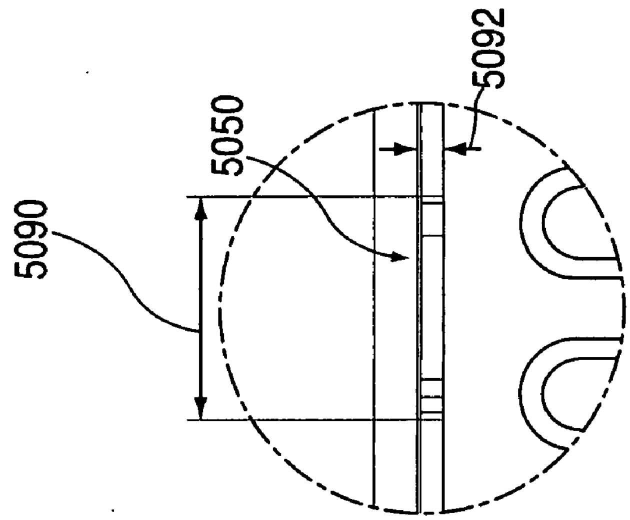


FIG. 50B

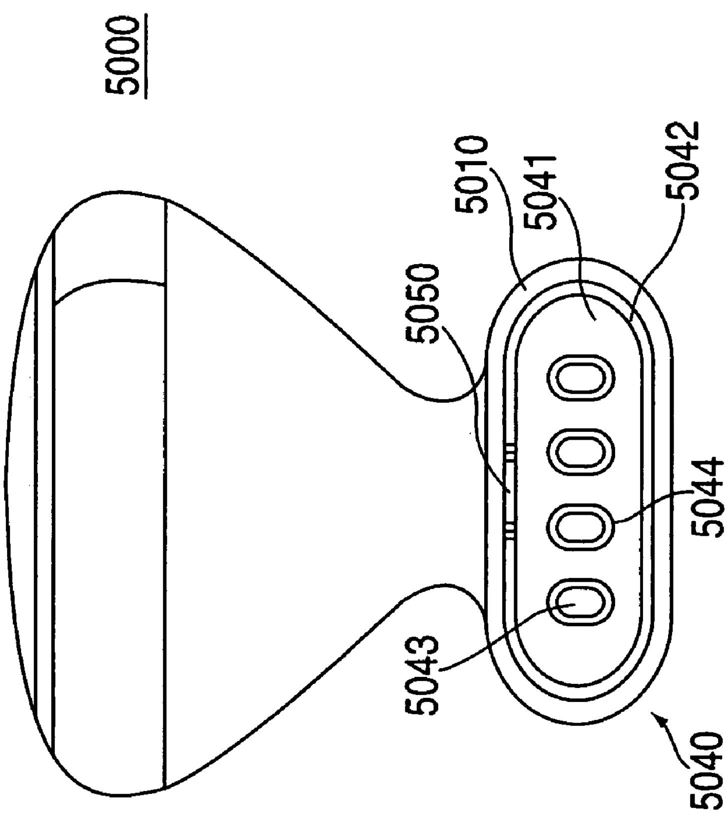


FIG. 50A

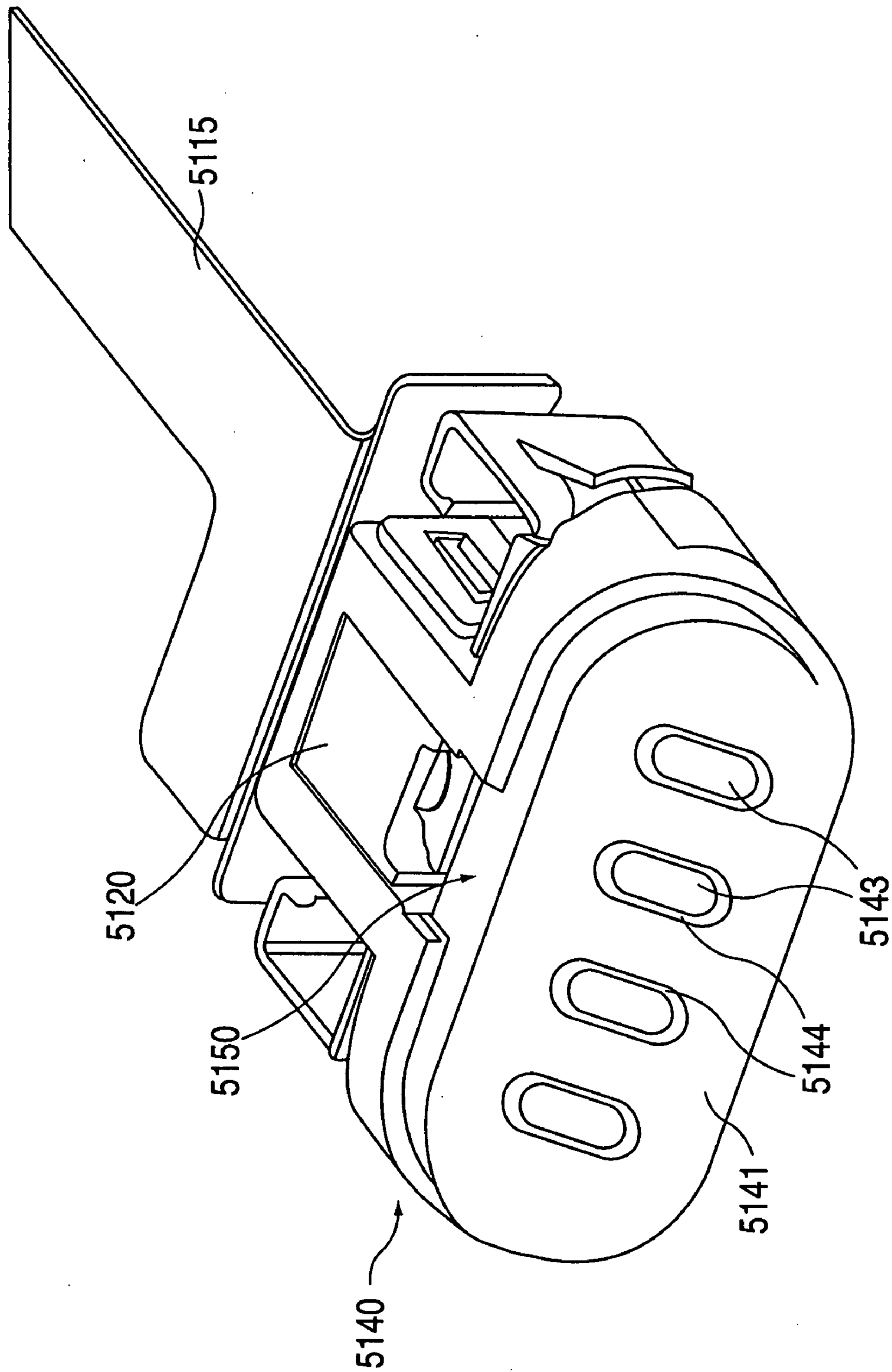


FIG. 51

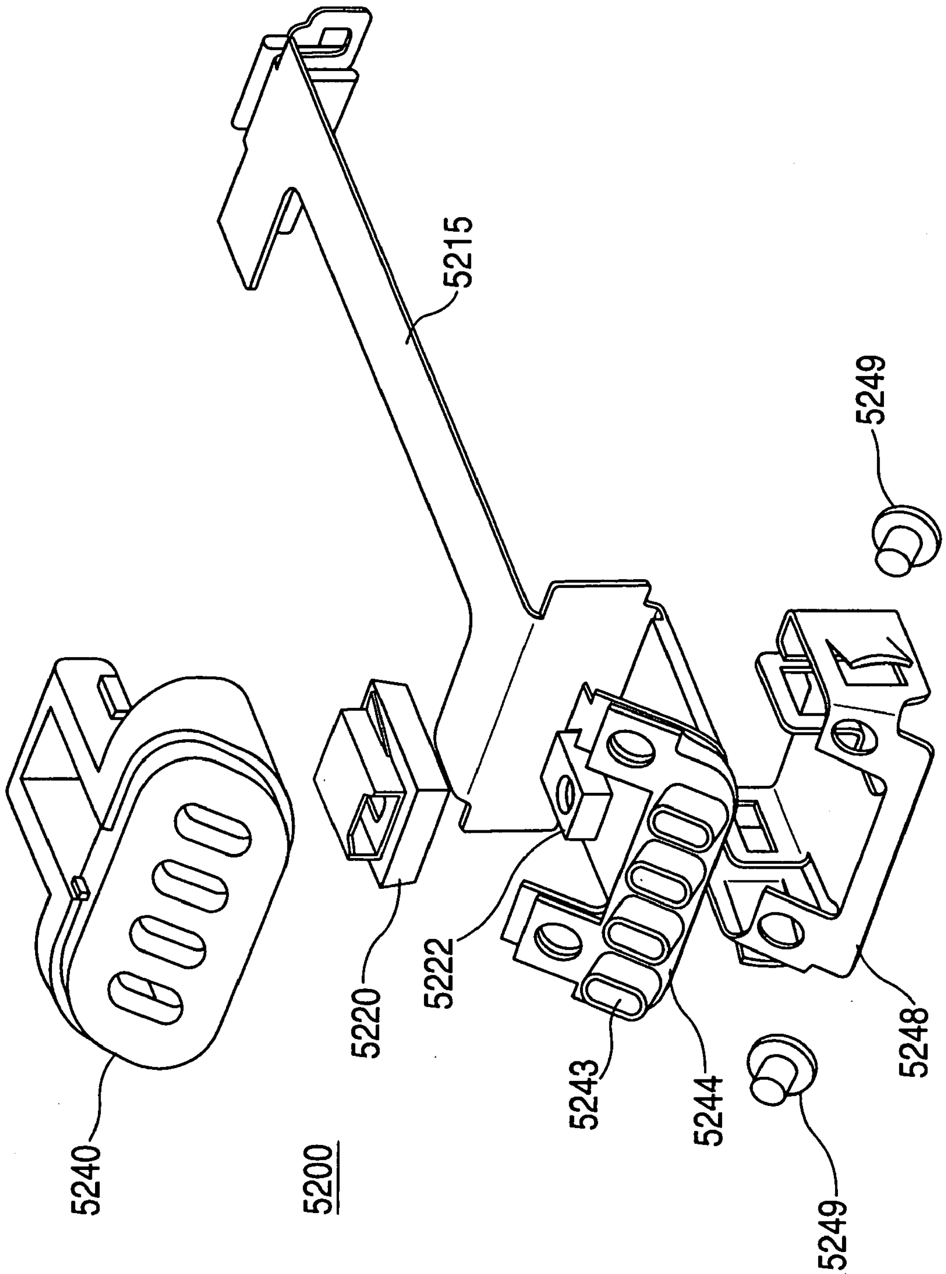


FIG. 52

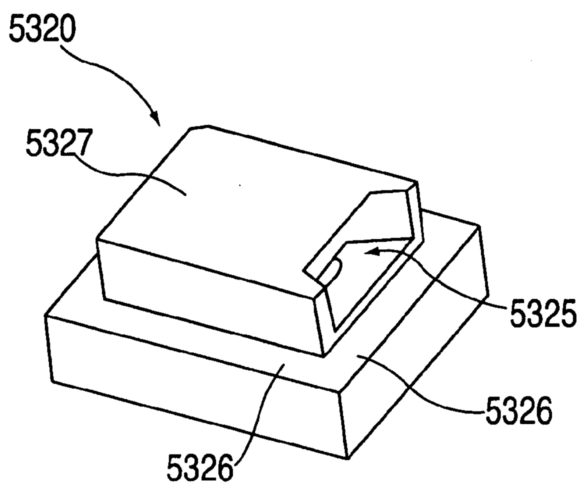

5320
5327
5325
5326
5326

FIG. 53

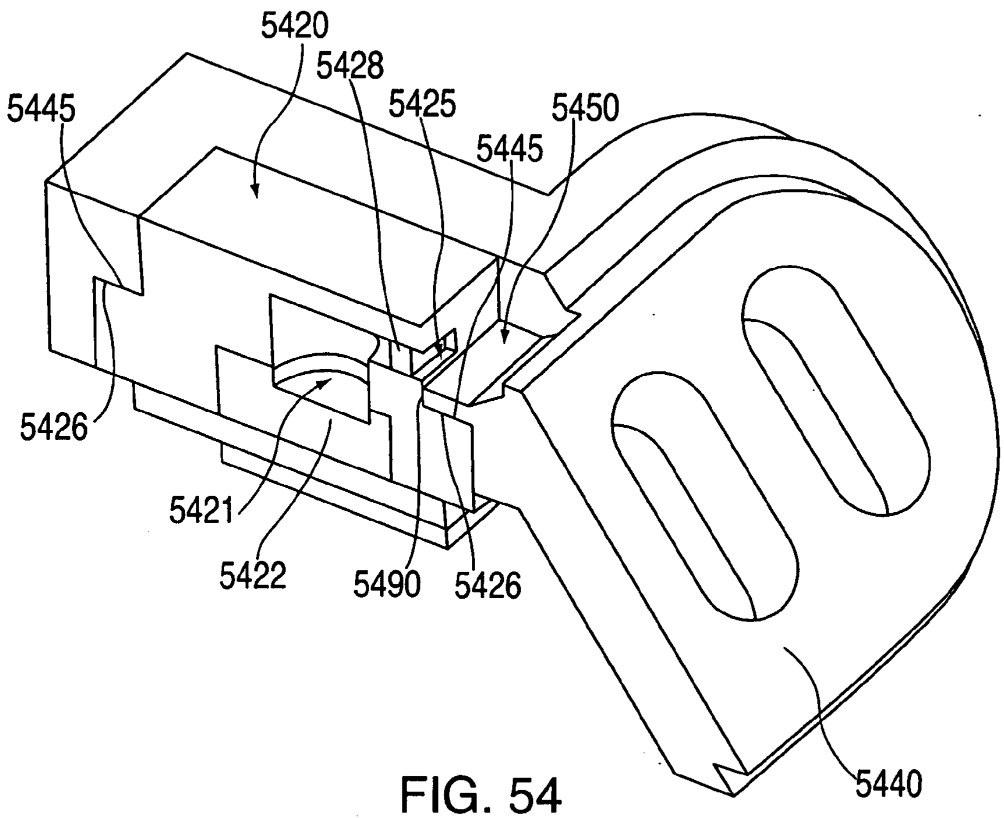

5420
5428
5445
5425
5450
5445
5426
5421
5422
5490
5426
5440

FIG. 54

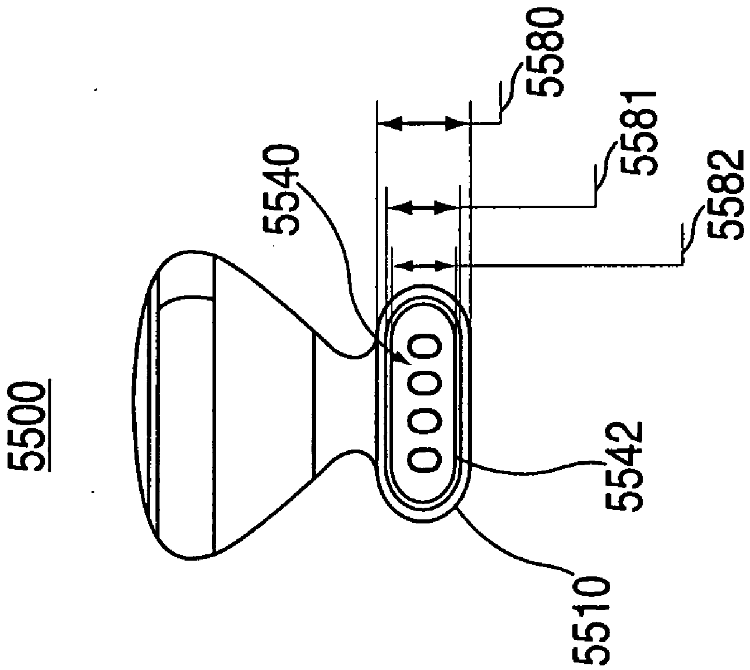


FIG. 55B

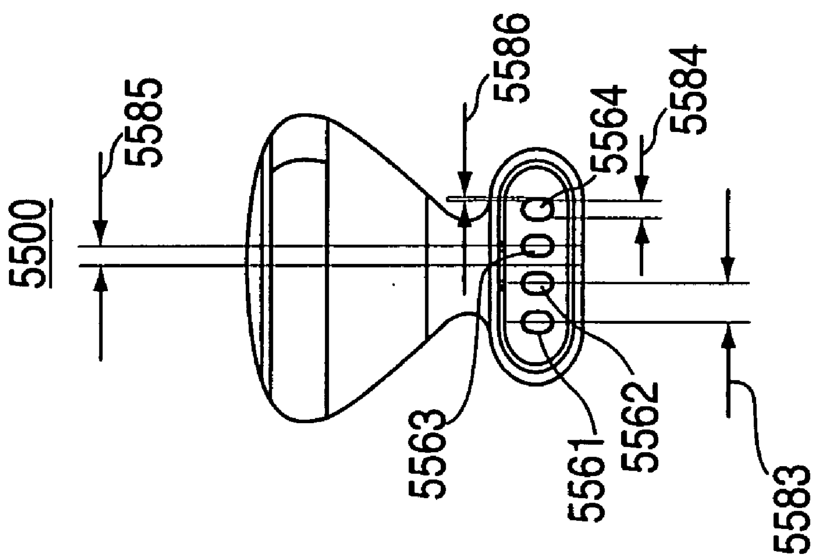


FIG. 55A

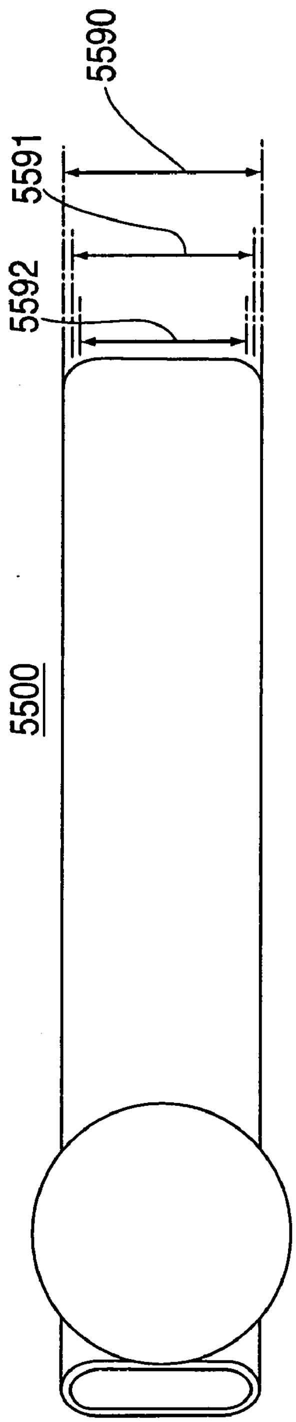


FIG. 55C

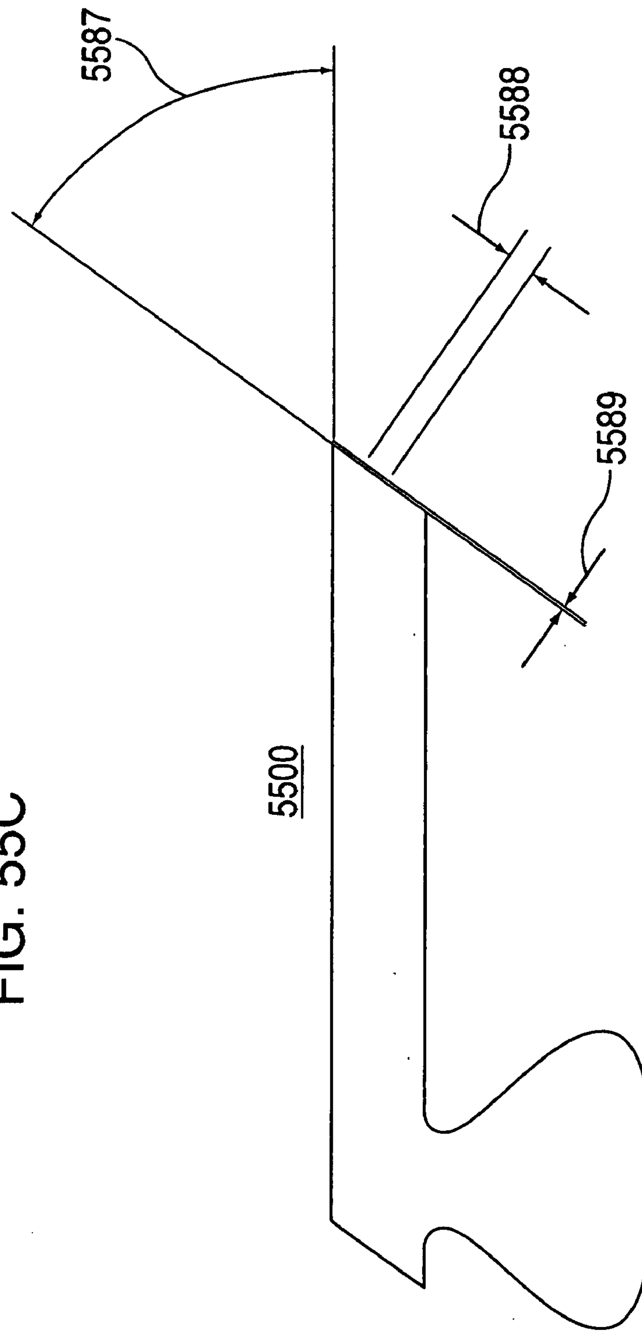


FIG. 55D

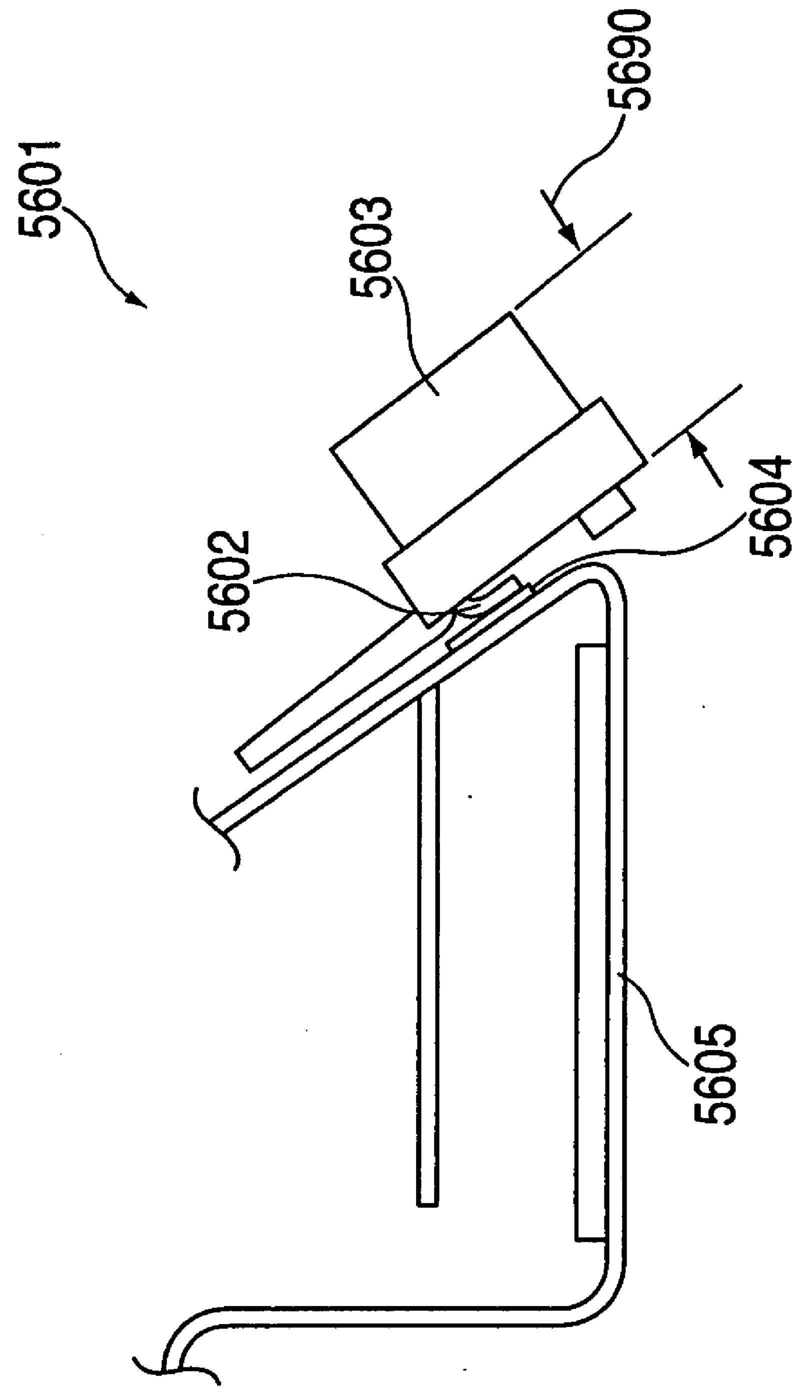


FIG. 56

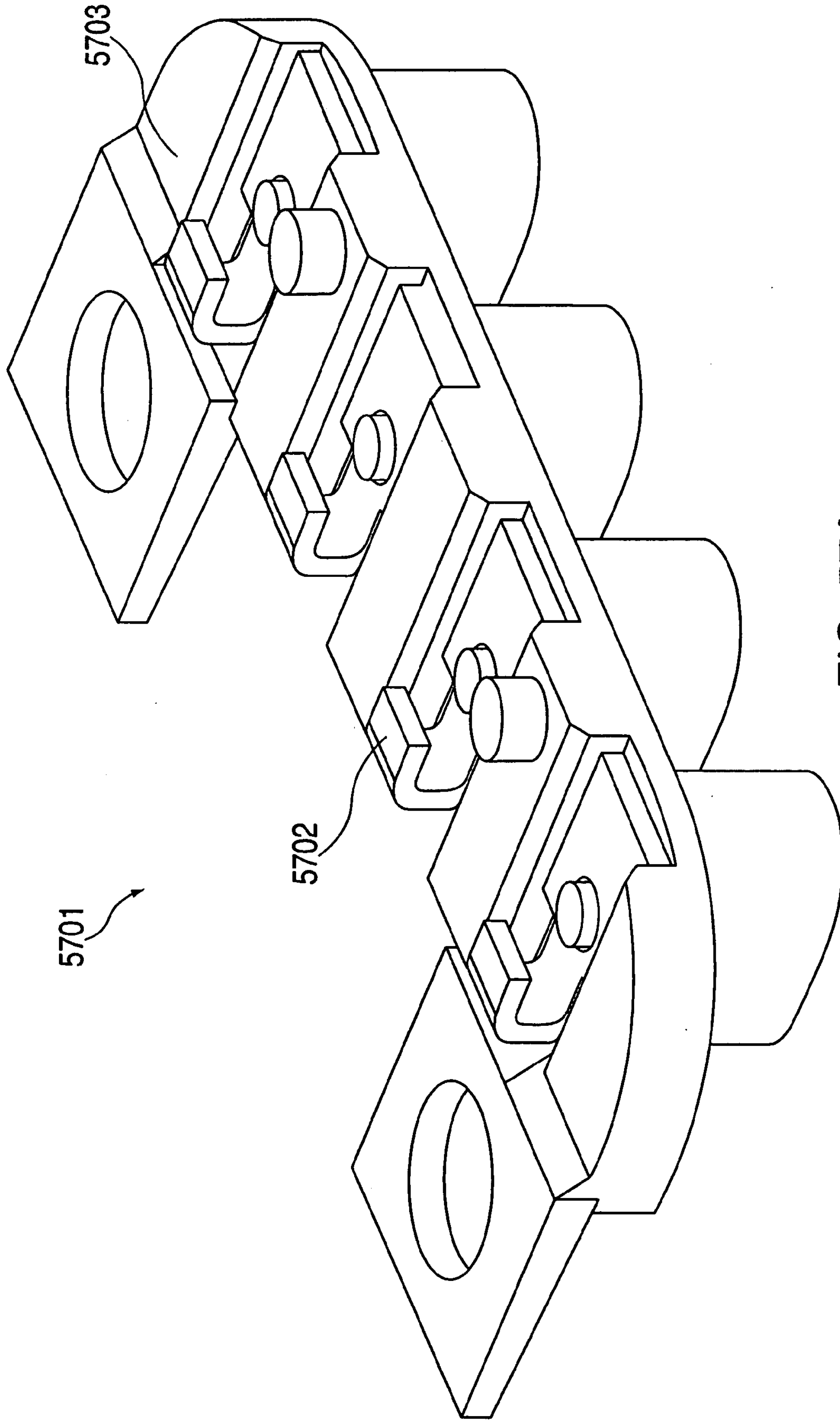


FIG. 57A

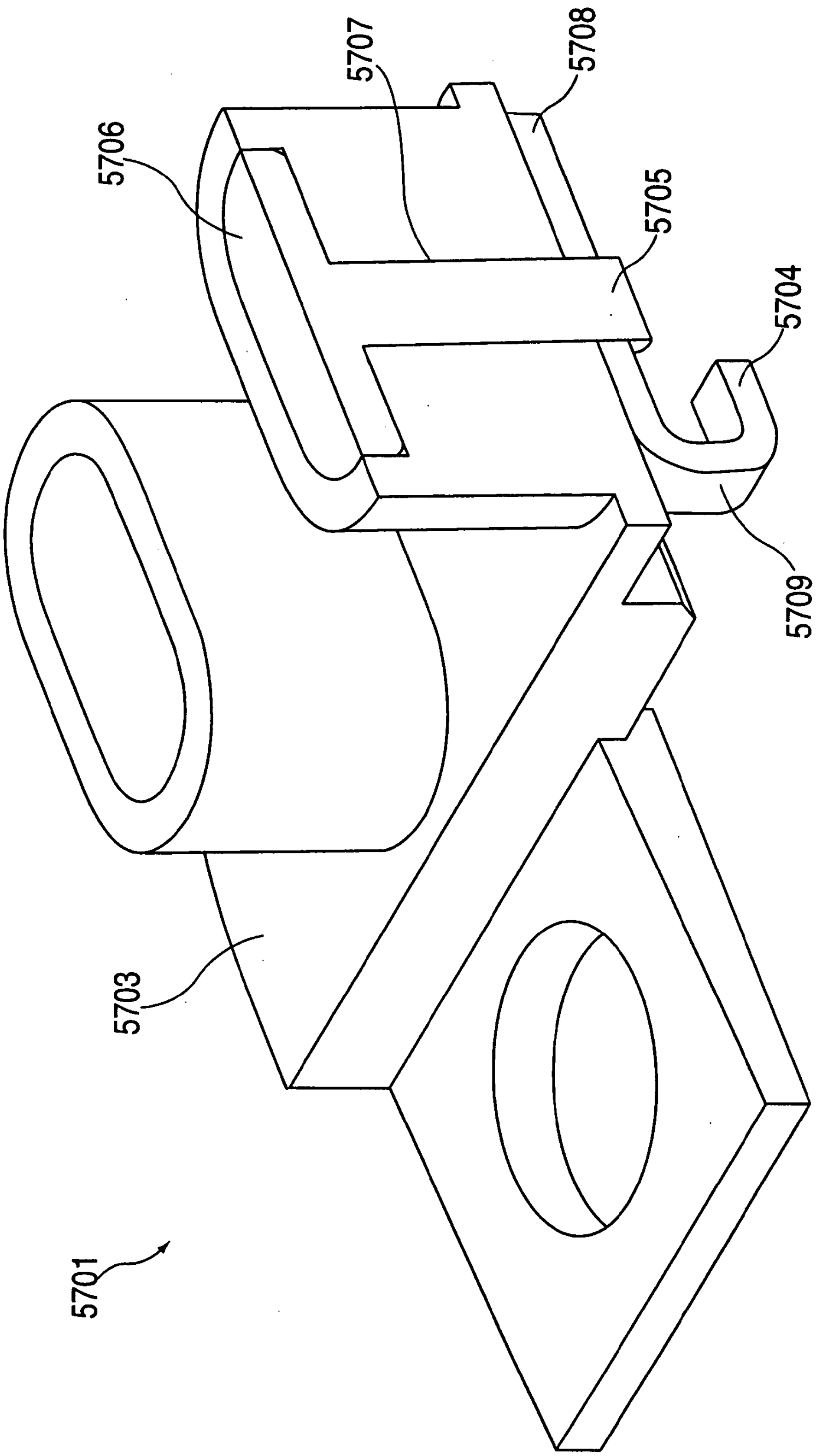


FIG. 57B

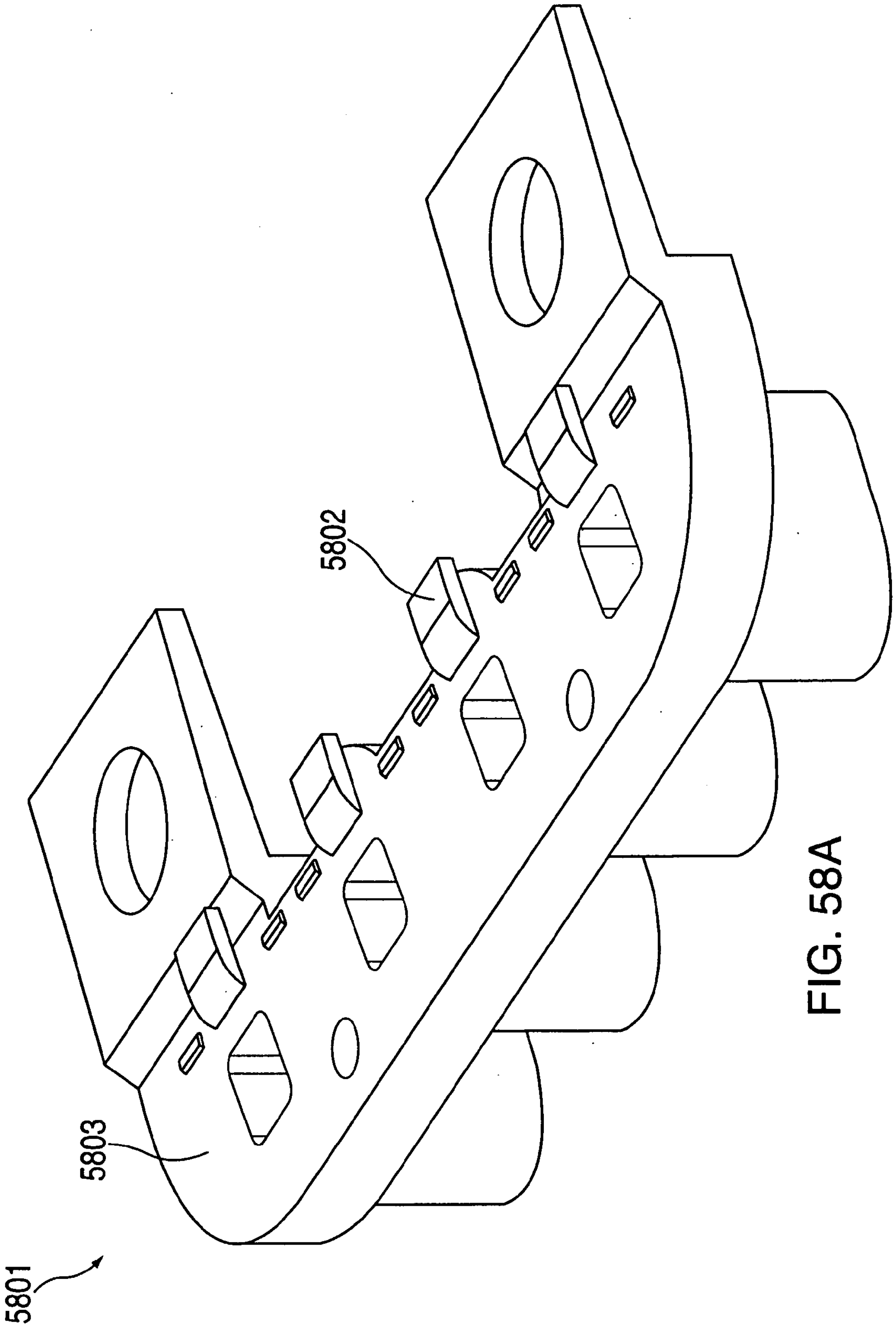


FIG. 58A

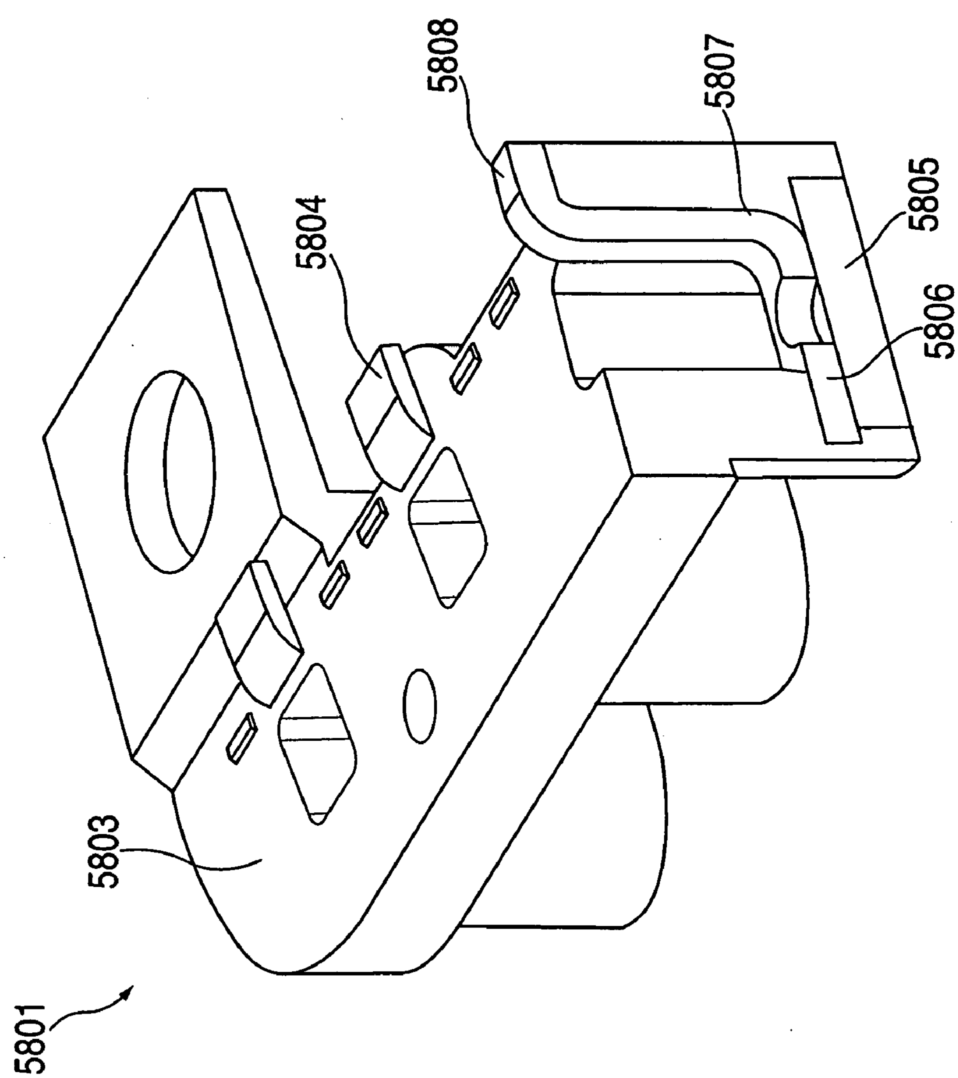


FIG. 58B

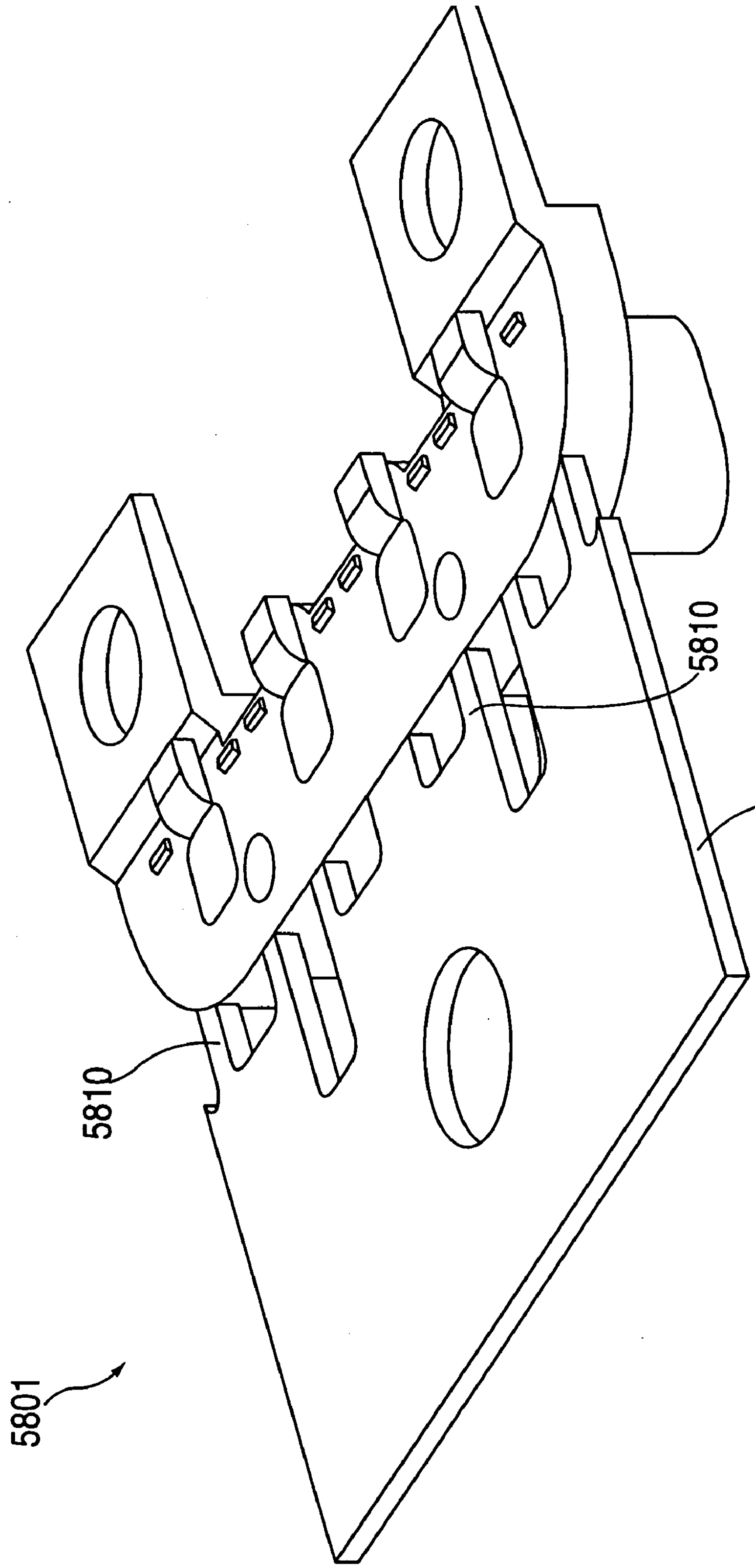


FIG. 58C

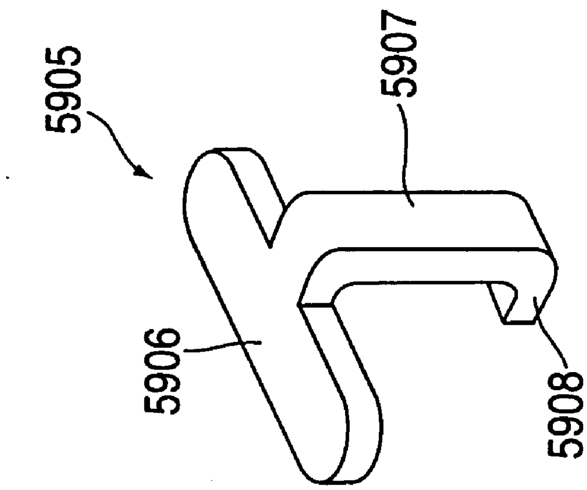


FIG. 59B

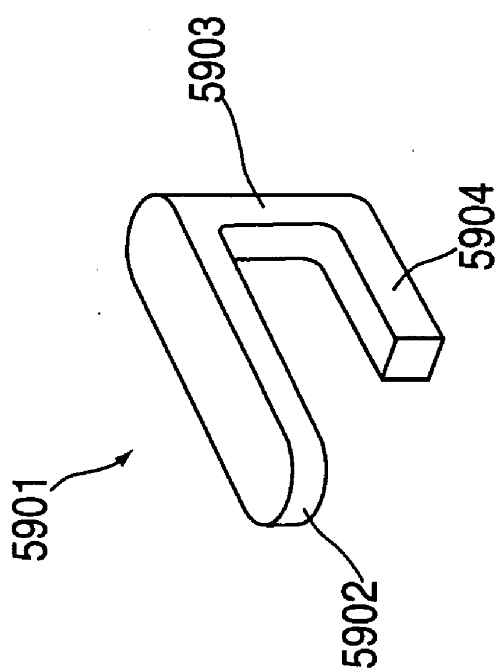


FIG. 59A

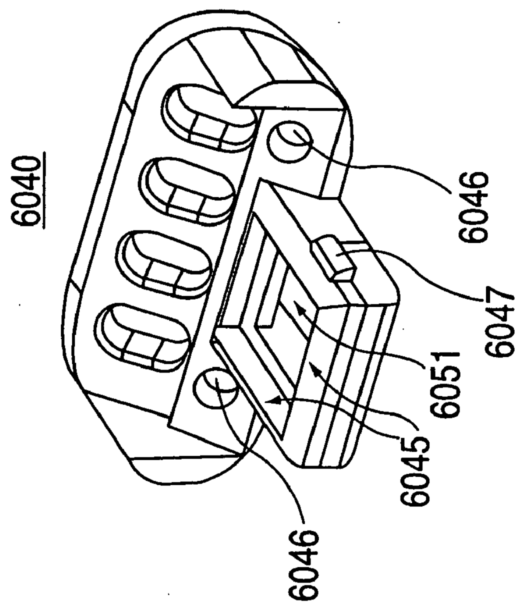


FIG. 60B

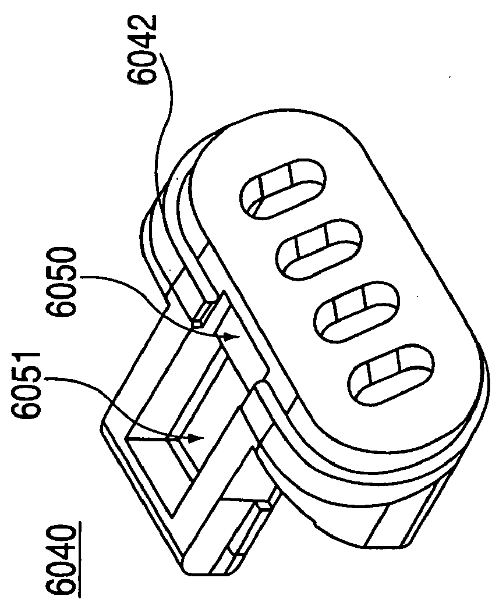


FIG. 60A

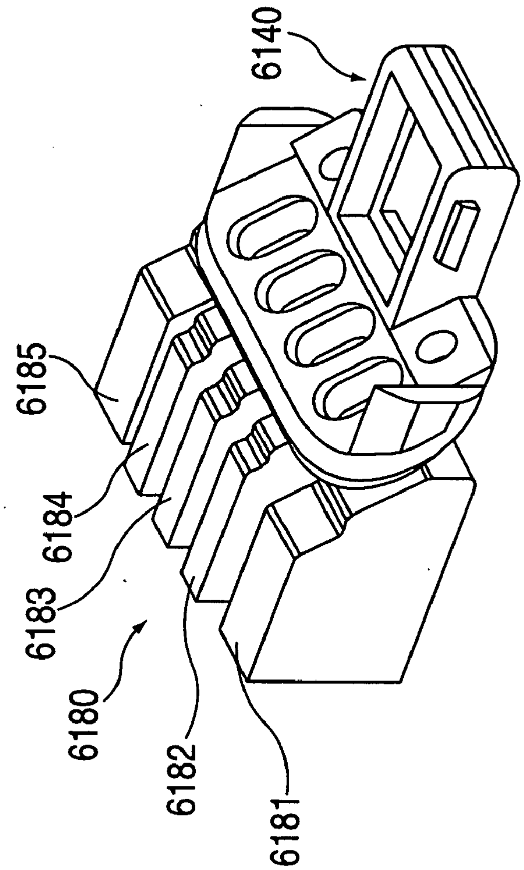


FIG. 61B

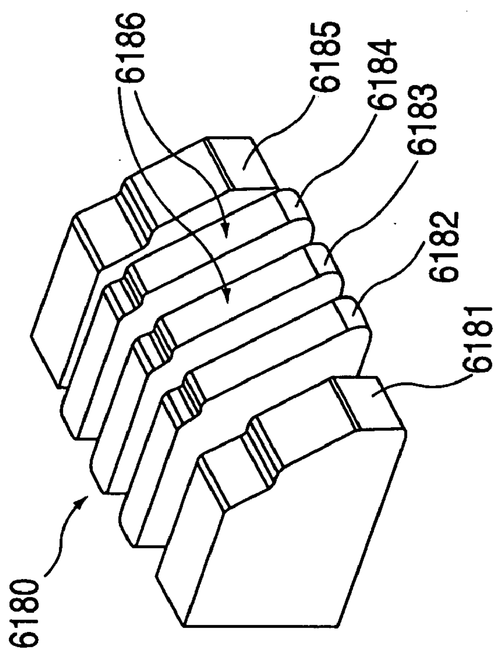


FIG. 61A

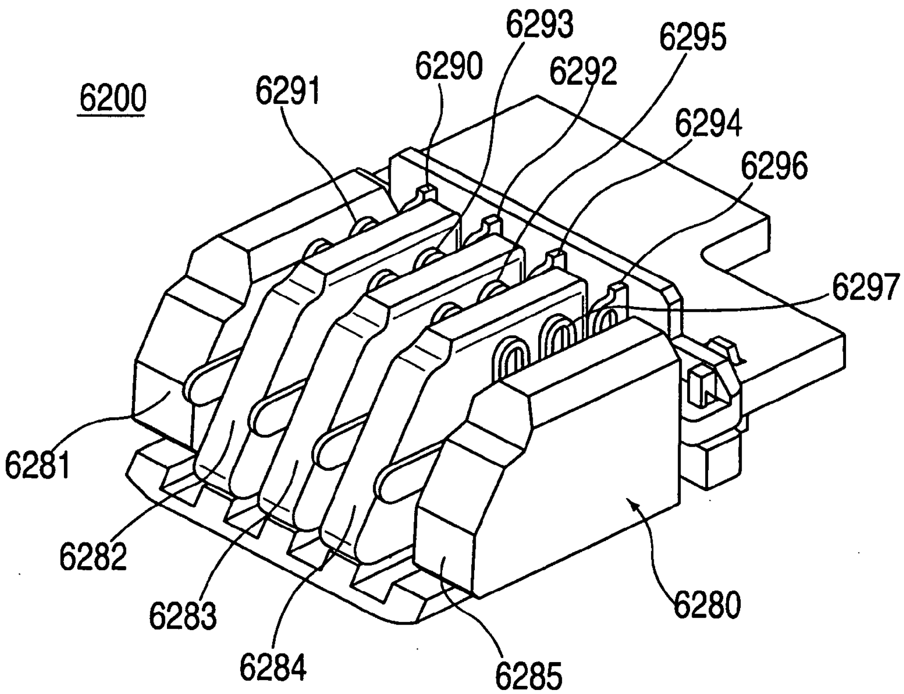


FIG. 62A

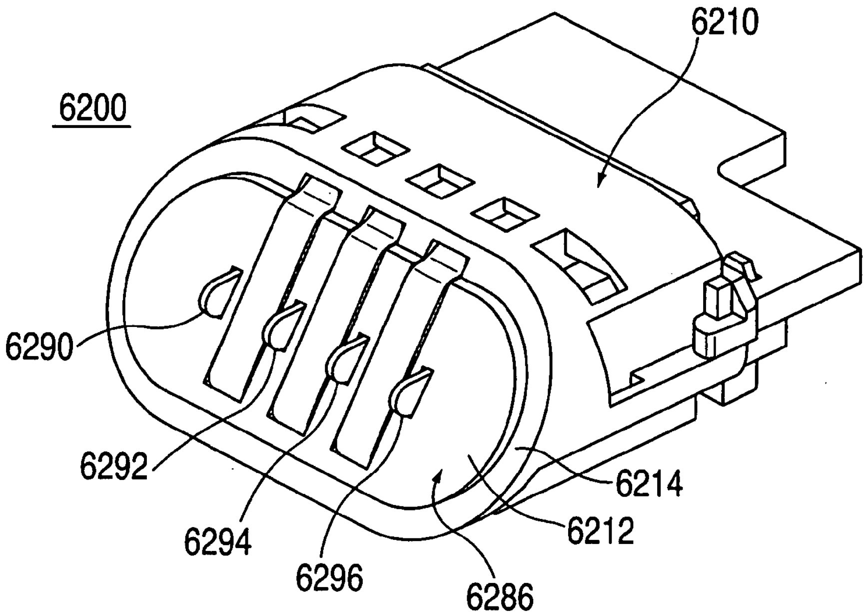


FIG. 62B

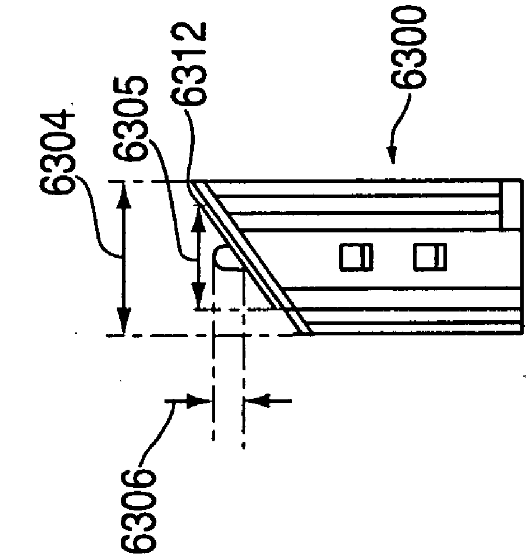


FIG. 63B

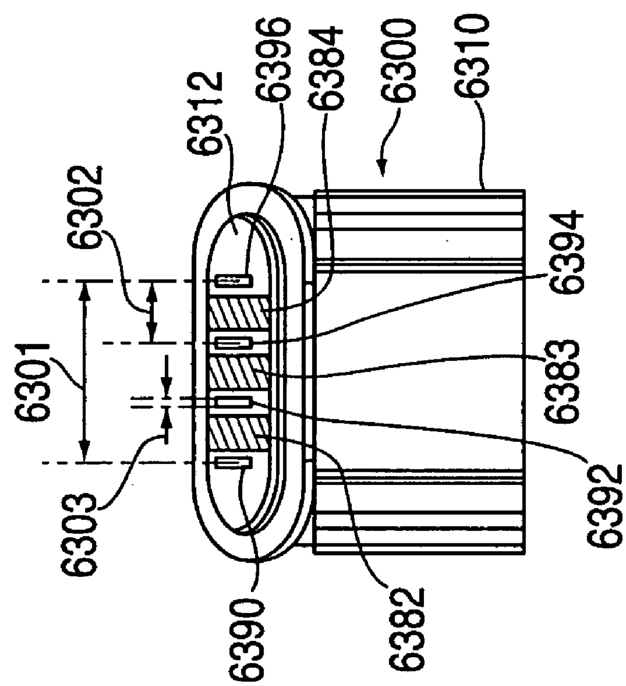
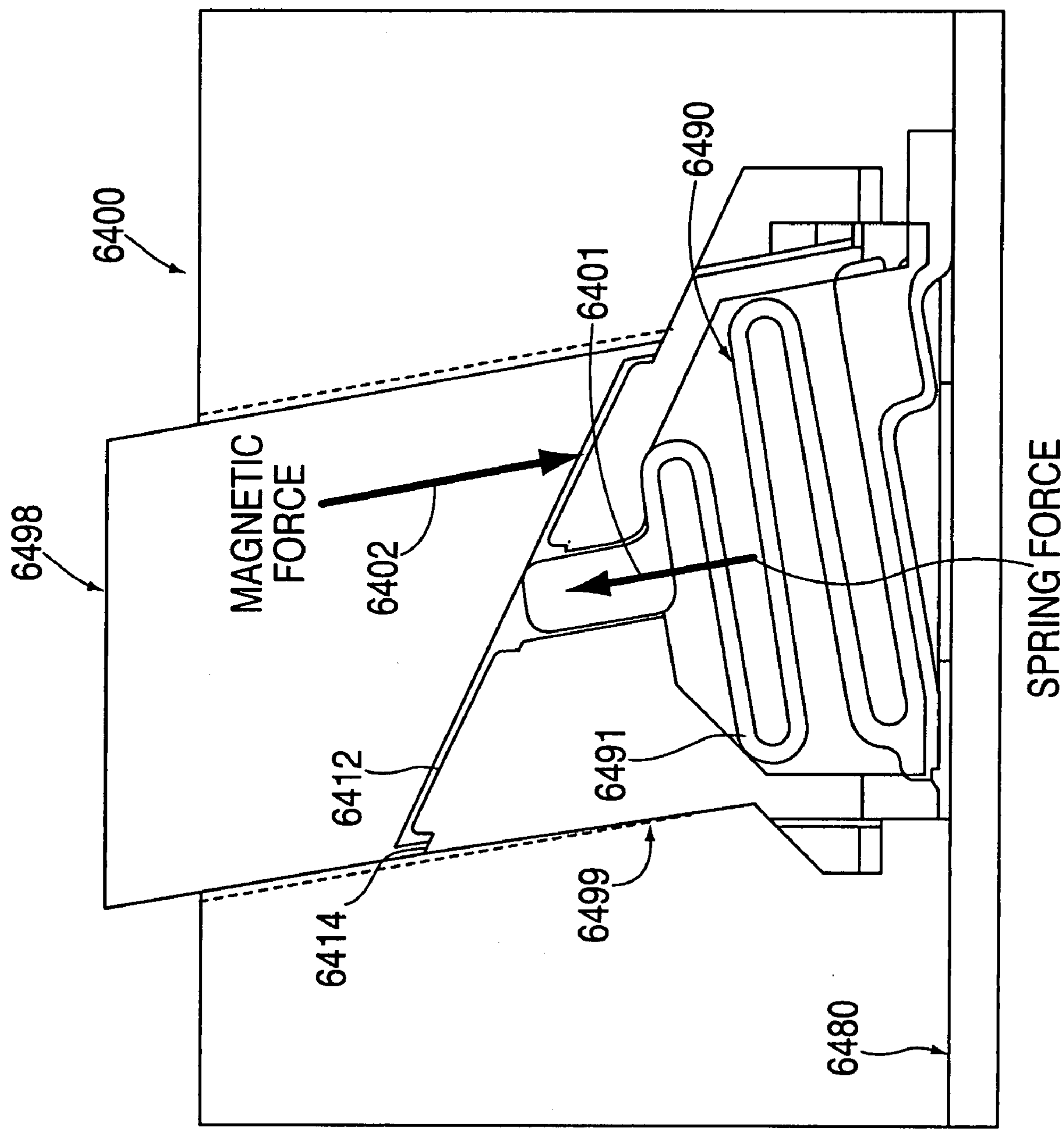


FIG. 63A

FIG. 64


6400
6498
MAGNETIC FORCE
6402
6401
6490
SPRING FORCE
6412
6414
6491
6499
6480

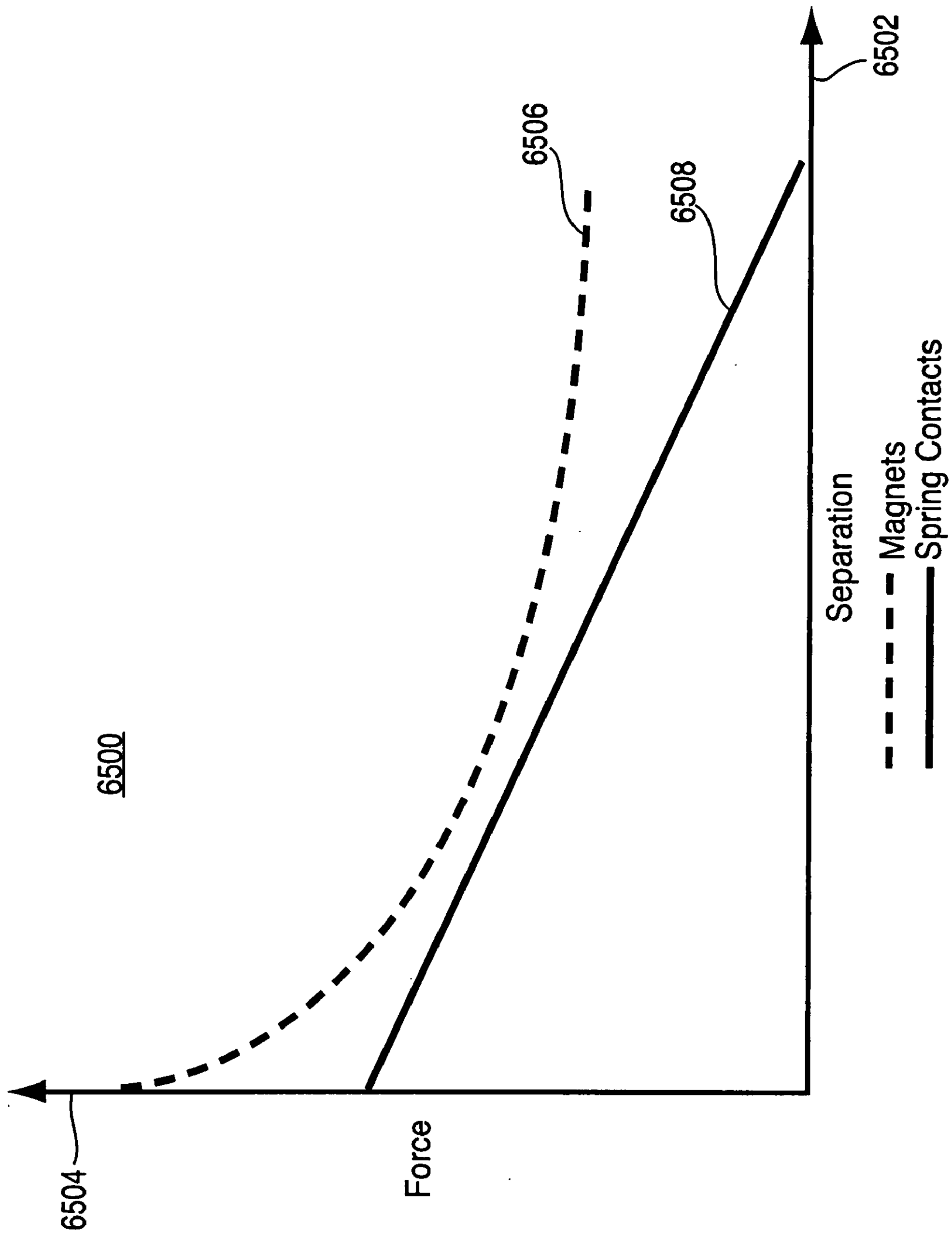

6500
6502
6506
6508
Separation
Magnets
Spring Contacts
6504
Force

FIG. 65

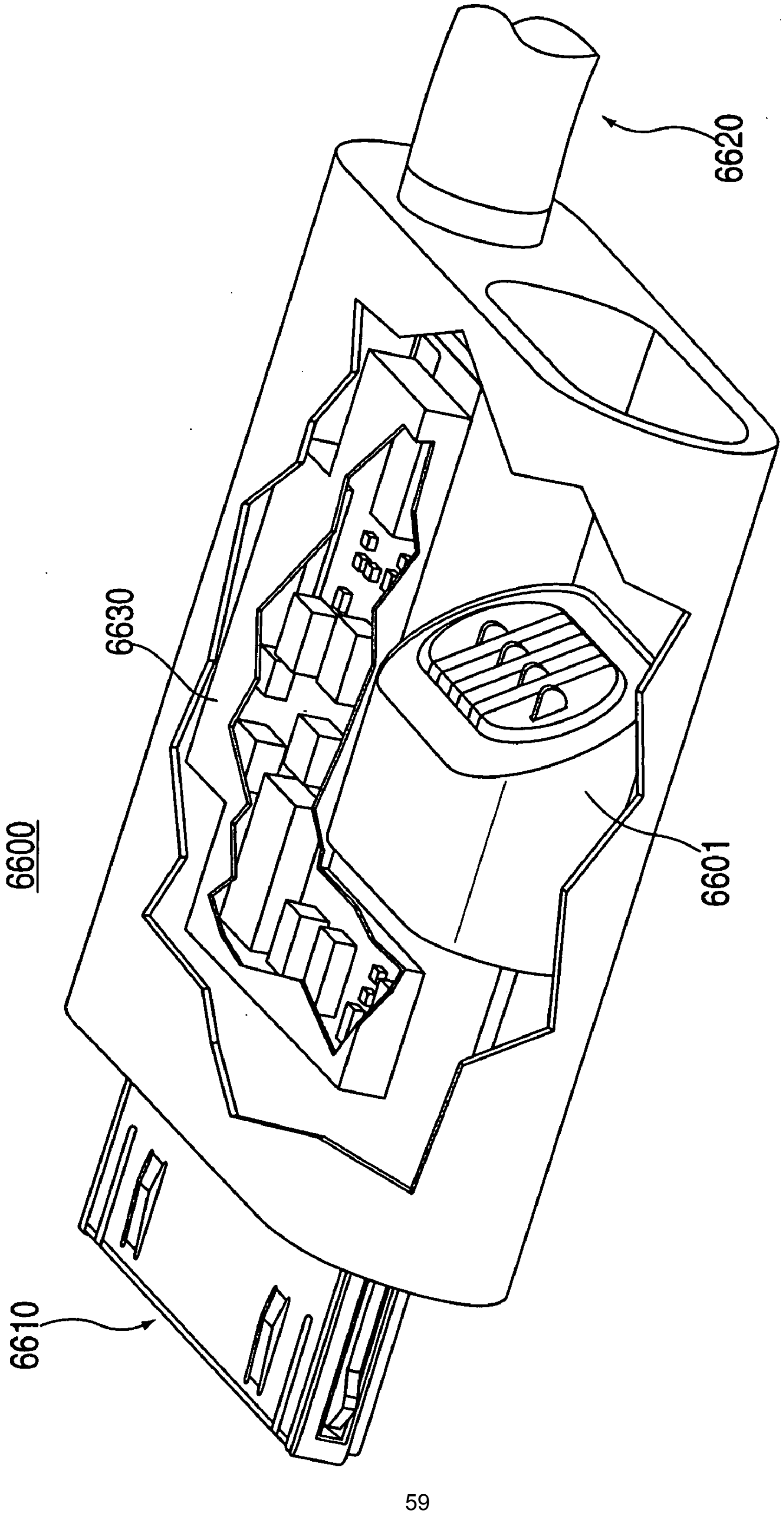


FIG. 66

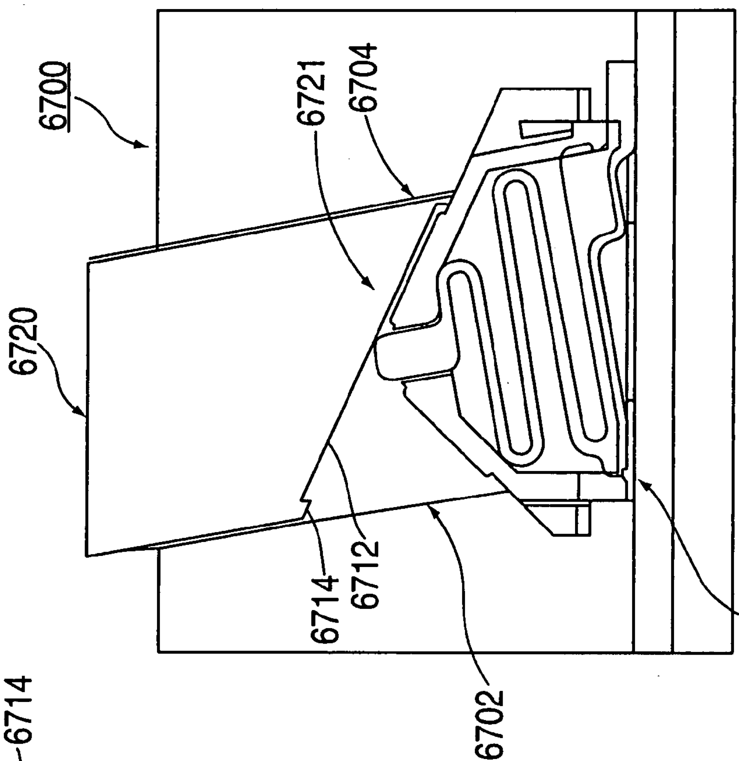


FIG. 67B

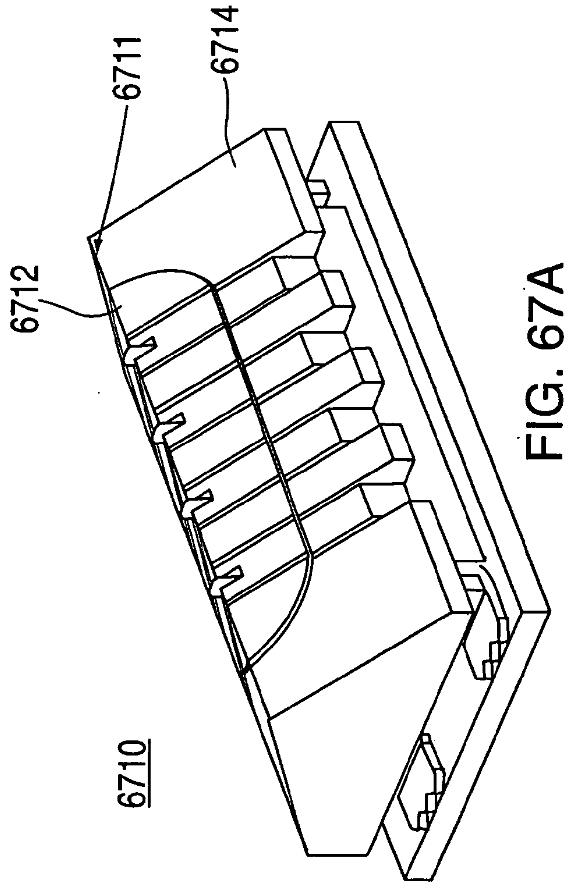


FIG. 67A

6800

	MODE (6810)	FUNCTION (6810)	HEADSET BUTTON PRESS (6820)	HEADSET DISPLAY SYSTEM (6830)	HEADSET AUDIO (6840)	HOST DEVICE UI (6850)
		TURN HEADSET ON	VERY LONG PRESS (2.5 SEC)	GREEN	4 RISING TONES	IF PAIRED, HEADSET ICON BECOMES BRIGHT
	HEADSET IN STANDBY		—	NONE	NONE	HEADSET ICON ON SCREEN IS BRIGHT
		CHECK ON STATUS	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT BEEP	N/A
		HEADSET DISCOVERABLE/ PAIRING	VERY, VERY LONG PRESS (8 SEC)	SOLID GREEN THEN FAST BLINKING GREEN	4 RISING TONES THEN 5 HIGH BEEPS	WIRELESS COMMUNICATIONS SCREEN
		TURN HEADSET OFF	VERY LONG PRESS (2.5 SEC)	GREEN THEN AMBER THEN OFF	4 FALLING TONES	HEADSET ICON TURNS DARK
	MISSED CALL		—	NONE	NONE	MISSED CALL INDICATOR SCREEN & ICONS
6811	INCOMING CALL		—	SLOW BLINKING GREEN	TWO BEEPS	INCOMING CALL SCREEN
6812		ANSWER CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT LOW TONE THEN SHORT HIGH TONE	CALL ANSWER SCREEN
6813		REJECT CALL	LONG PRESS, RELEASE (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL REJECT SCREEN
	HEADSET ON CALL		—	NONE	YES	CALL IN PROGRESS SCREEN
		MUTE ON	N/A	NONE	NONE	MUTE ICON
		CALL ON HOLD	N/A	NONE	NONE	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
		END CALL	SHORT TAP	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	CALL ENDED SCREEN
	INCOMING CALL WHILE ON CALL		—	NONE	DOUBLE LOW TONE (HANDSET DEPENDENT)	HOST DEVICE GENERATE AUDIO/TONE, CALL WAITING ALERT SCREEN
		SWITCH CALL	SHORT TAPE	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
6814		END CALL, ACTIVATE OTHER CALL	LONG PRESS (1 SEC)	GREEN UNTIL BUTTON RELEASE	SHORT DOUBLE LOW TONE	IN CALL SCREEN
	LOST LINK		—	N/A	SHORT DOUBLE LOW TONE	HEADSET OUT OF RANGE WARNING
		RECONNECT	N/A	N/A	NONE	HEADSET ICON BLINKS THEN CHANGES COLORS
	LOW BATTERY		—	N/A	LONG HIGH BEEP	NONE
	CONNECTED TO BATTERY		—	CHARGING - SOLID AMBER CHARGED - SOLID GREEN	NONE	BATTERY CHARGE SCREEN

FIG. 68

HEADSET WITH MICROPHONE AND CONNECTOR CO-LOCATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of certain copending, commonly assigned U.S. Provisional Patent Applications, namely, Ser. No. 60/878,852 filed on Jan. 5, 2007; Ser. No. 60/879,177 filed on Jan. 6, 2007; Ser. No 60/879,193 filed on Jan. 6, 2007; Ser. No. 60/879,195 filed on Jan. 6, 2007; and Ser. No. ______ filed on Jun. 22, 2007 (Attorney Docket No. 104677-0102-001 (P5389USP1)), entitled "Single User Input Mechanism for Controlling Electronic Device Operations"; all of which are incorporated herein by reference.

[0002] Commonly assigned DiFonzo et al. U.S. patent application Ser. No. 11/235,873, filed Sep. 26, 2005 (Attorney Docket No. P3794US1/119-0060US.1), entitled "Electromagnetic Connector for Electronic Device" is hereby incorporated by reference in its entirety.

[0003] Commonly assigned Rohrbach et al. U.S. patent application Ser. No. 11/235,875, filed Sep. 26, 2005 (Attorney Docket No. P3593US1/119-0060US), entitled "Magnetic Connector for Electronic Device" is hereby incorporated by reference in its entirety.

[0004] Commonly assigned Andre et al. U.S. patent application Ser. No. 11/456,833, filed Jul. 11, 2006 (Attorney Docket No. P3981US1), entitled "Invisible, Light-Transmissive Display System" is hereby incorporated by reference in its entirety.

[0005] Commonly assigned Andre et al. U.S. patent application Ser. No. 11/551,988, filed Oct. 23, 2006 (Attorney Docket No. P4246USX1), entitled "Invisible, Light-Transmissive Display System" is hereby incorporated by reference in its entirety.

[0006] Commonly assigned Sanford et al. U.S. patent application Ser. No. 11/651,094, filed Jan. 6, 2007 (Attorney Docket No. P4983US2), entitled "Antenna and Button Assembly for Wireless Devices" is hereby incorporated by reference in its entirety.

[0007] Commonly assigned Terlizzi et al. U.S. patent application Ser. No. 11/650,130, filed Jan. 5, 2007 (Attorney Docket No. 104677-0015-101 (P4630US1)), entitled "Systems and Methods for Determining the Configuration of Electronic Connections" is hereby incorporated by reference in its entirety.

[0008] Commonly assigned Rabu et al. U.S. patent application Ser. No. 11/620,669, filed Jan. 6, 2007 (Attorney Docket No. 104677-0011-102 (P4628US2)), entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" is hereby incorporated by reference in its entirety.

FIELD OF INVENTION

[0009] The present invention can relate to headsets. More particularly, the present invention can relate to headsets for communicating with an electronic device.

BACKGROUND OF THE INVENTION

[0010] Headsets for providing hands-free communications are known in the art. Such headsets typically can be used in conjunction with a cellular telephone or a computer (e.g., Voice over IP). Some existing headsets include a microphone, a speaker (also referred to as a receiver), electronics for controlling the headset and communicating with another device (e.g., a cellular telephone), a battery and a connector for re-charging the battery.

[0011] There are many aspects involved in the design of headsets. For example, the size and weight of headsets can be key issues because of how they typically mount to a user's ear. A heavy or large headset can pull on a user's ear, creating an uncomfortable fit. The shape of headset earpieces (e.g., earbuds) may also be an important design consideration to take into account as it is desirable for earpieces to fit comfortably in, on, or over a wide range of different sizes and shapes of ears.

[0012] Additionally, the acoustic performance of headsets, such as receiver sound generation quality and microphone sound reception quality (e.g., ability to pick up a user's voice without undue background noise), can be important design considerations. Achieving desired receiver and microphone acoustic performance can become increasingly difficult as the size of a headset decreases.

[0013] Another example of an important design consideration can be the user interface of a headset. It may be desirable for a user interface to be intuitive for a first-time user, yet convenient for an experienced user.

[0014] Aesthetics may be yet another important, design consideration for headsets.

[0015] Further still, ease of manufacturing headsets can be another design consideration. For example, it can be desirable to design a headset that can be mass produced in an affordable fashion.

[0016] In view of the foregoing, there is a need for an improved headset that addresses one or more of the above-identified considerations.

SUMMARY OF THE INVENTION

[0017] In accordance with one embodiment of the present invention, an electronic device is provided. The electronic device can include a housing and a connector assembly coupled to the housing. The connector assembly can include a microphone port. The electronic device can include a microphone mounted within the housing and a channel that fluidically couples the microphone to the microphone port.

[0018] In accordance with another embodiment of the present invention, a joint connector and microphone assembly is provided. The assembly can include a microphone with a top surface and side surfaces. The top surface of the microphone can include a microphone input. The assembly can include a microphone boot mounted to the microphone such that the boot interfaces with a portion of the top surface and the side surfaces to form a seal around the microphone input. The microphone boot can include a connector sealing portion and an aperture for fluidically coupling the microphone input to a microphone port. The assembly can include a connector plate mounted to the connector sealing portion.

[0019] In accordance with yet another embodiment of the present invention, an electronic device is provided. The device can include an earbud assembly and a primary housing assembly fixed to the earbud assembly. The primary housing assembly can include an integrated connector and microphone assembly. The integrated connector and microphone assembly can include a microphone port and a microphone operative to receive acoustic signals transmitted through the microphone port.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention will be apparent upon consideration of the following detailed description, taken in conjunction with accompanying drawings, in which:

[0021] FIG. **1** is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0022] FIG. **2** is a simplified block diagram of a headset connector system in accordance with an embodiment of the present invention;

[0023] FIG. **3** is a simplified cross-sectional illustration of a connector assembly in accordance with an embodiment of the present invention;

[0024] FIG. **4** is a simplified cross-sectional illustration of another connector assembly in accordance with an embodiment of the present invention;

[0025] FIG. **5** is a simplified block diagram of a headset in accordance with an embodiment of the present invention;

[0026] FIG. **6**A is a simplified cross-sectional illustration of a portion of a headset in accordance with an embodiment of the present invention;

[0027] FIG. **6**B is a simplified cross-sectional illustration of a screw in accordance with an embodiment of the present invention;

[0028] FIG. **7** is a simplified block diagram of a display system in accordance with an embodiment of the present invention;

[0029] FIG. **8** is a simplified block diagram of a power distribution system in accordance with an embodiment of the present invention;

[0030] FIG. **9** is a simplified block diagram of another power distribution system in accordance with an embodiment of the present invention;

[0031] FIGS. **10**A and **10**B are illustrations of a headset in accordance with an embodiment of the present invention;

[0032] FIG. **11** is an exploded view of a headset in accordance with an embodiment of the present invention;

[0033] FIG. **12** is an exploded view of a headset in accordance with another embodiment of the present invention;

[0034] FIG. **13** is a simplified diagram showing how software in a Bluetooth device is organized in accordance with an embodiment of the present invention;

[0035] FIG. **14** is a simplified block diagram of the electrical system of a headset in accordance with an embodiment of the present invention;

[0036] FIG. **15** is a simplified block diagram of the core processor of a headset in accordance with an embodiment of the present invention;

[0037] FIG. **16** is a simplified schematic diagram of a power distribution system in accordance with an embodiment of the present invention;

[0038] FIGS. **17**A-**17**C are illustrations of a traditional circuit board and distribution of electrical components in a headset;

[0039] FIG. **18** is a simplified block diagram of a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0040] FIG. **19**A and **19**B are illustrations comparing the traditional circuit board of FIGS. **7**A-**7**C to a circuit board with an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0041] FIG. **20**A-**20**C are illustrations of an improved distribution of electrical components in a headset in accordance with an embodiment of the present invention;

[0042] FIG. **21**A is an illustration of a headset earbud in accordance with an embodiment of the present invention;

[0043] FIG. **21**B is a simplified exploded view of a headset earbud in accordance with an embodiment of the present invention;

[0044] FIGS. **22**-**25** and FIG. **26**A are simplified illustrations of a headset earbud in various states of assembly in accordance with some embodiments of the present invention;

[0045] FIG. **26**B is a simplified cross-sectional view of an audio receiver in accordance with an embodiment of the present invention;

[0046] FIG. **27**A is a simplified cross-sectional view of a partially assembled headset earbud in accordance with an embodiment of the present invention;

[0047] FIG. **27**B is a simplified cross-sectional view of a fully assembled headset earbud in accordance with an embodiment of the present invention;

[0048] FIG. **28** is an exploded view of an attachment system in accordance with an embodiment of the present invention;

[0049] FIG. **29** is a flowchart of an illustrative process for assembling a portion of a headset in accordance with an embodiment of the present invention.

[0050] FIGS. **30**A and **30**B are illustrations of a tool that can be used to assist in assembly of a portion of a headset in accordance with an embodiment of the present invention;

[0051] FIG. **30**C is an illustration of the tool of FIGS. **30**A and **30**B being used in accordance with an embodiment of the present invention;

[0052] FIG. **31** is a cross-sectional view of a "finished" tube in accordance with an embodiment of the present invention;

[0053] FIG. **32** is a cross-sectional view of an initially manufactured tube in accordance with an embodiment of the present invention;

[0054] FIG. **33** is a perspective view of a cross section of the tube of FIG. **31** in accordance with an embodiment of the present invention;

[0055] FIG. **34** is an illustrative die and stamper for modifying the initially manufactured tube of FIG. **32** in accordance with an embodiment of the present invention;

[0056] FIG. **35** is a cross-sectional view of the tube of FIG. **34** once the stamper and die are removed from the tube in accordance with an embodiment of the present invention;

[0057] FIG. **36** is a perspective view of the tube of FIG. **35** once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0058] FIG. **37** is a cross-sectional view of an illustrative tube formed using a single impact extrusion in accordance with an embodiment of the present invention;

[0059] FIG. **38** is a perspective view of the tube of FIG. **37** once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0060] FIG. **39** is a cross-sectional view of an illustrative tube formed using a double impact extrusion in accordance with an embodiment of the present invention;

[0061] FIG. **40** is a perspective view of the tube of FIG. **39** once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0062] FIG. **41** is a cross-sectional view of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present invention;

[0063] FIG. **42** is a perspective view of a cross section of the tube of FIG. **41** in accordance with an embodiment of the present invention;

[0064] FIG. **43** is a perspective view of the tube of FIGS. **41** and **42** once the tube is machined to create an internal wall in accordance with an embodiment of the present invention;

[0065] FIG. **44** is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube with using a die and stamper in accordance with an embodiment of the present invention;

[0066] FIG. **45** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention;

[0067] FIG. **46** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention;

[0068] FIG. **47** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention;

[0069] FIG. **48** is a cross-sectional view of a visual indicator system in accordance with an embodiment of the present invention;

[0070] FIG. **49** is an illustration of a visual indicator system of a headset in accordance with an embodiment of the present invention;

[0071] FIGS. **50**A and **50**B are illustrations of a headset in accordance with an embodiment of the present invention;

[0072] FIG. **51** is an illustration of a connector in accordance with an embodiment of the present invention;

[0073] FIG. **52** is an exploded view of a connector in accordance with an embodiment of the present invention;

[0074] FIG. **53** is an illustration of a microphone boot in accordance with an embodiment of the present invention;

[0075] FIG. **54** is a cross-sectional view of a connector in accordance with an embodiment of the present invention;

[0076] FIGS. **55**A-**55**D are illustrations of a headset in accordance with an embodiment of the present invention;

[0077] FIG. **56** is a cross-sectional view of an electrical contact assembly coupled to a circuit board in accordance with an embodiment of the present invention;

[0078] FIGS. **57**A and **57**B are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0079] FIGS. **58**A-**58**C are illustrations of an electrical contact assembly in accordance with an embodiment of the present invention;

[0080] FIGS. **59**A and **59**B are illustrations of electrical contacts in accordance with an embodiment of the present invention;

[0081] FIGS. **60**A and **60**B are illustrations of a connector plate in accordance with an embodiment of the present invention;

[0082] FIGS. **61**A and **61**B are illustrations of magnetic components of a connector in accordance with an embodiment of the present invention;

[0083] FIGS. **62**A and **62**B are illustrations of a connector in accordance with an embodiment of the present invention;

[0084] FIGS. **63**A and **63**B are illustrations of a connector in accordance with an embodiment of the present invention;

[0085] FIG. **64** is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention;

[0086] FIG. **65** is a simplified graph of magnetic and spring forces involved in the coupling of a headset with a complementary connector in accordance with an embodiment of the present invention;

[0087] FIG. **66** is an illustration of a docking device that can receive a headset in accordance with an embodiment of the present invention;

[0088] FIG. **67**A is an illustration of a connector in accordance with an embodiment of the present invention;

[0089] FIG. **67**B is an illustration of a headset coupling with a complementary connector in accordance with an embodiment of the present invention; and

[0090] FIG. **68** is a chart listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0091] The present invention relates to headsets and methods for manufacturing the same. Headsets are communication devices that are worn on a user's head in order to allow hands free data and/or voice communication with a host device such as a computer, phone handset, cellular phone, an automobile and/or the like. Headsets can include one or more speakers (in proximity to one or both ears) for audio output and/or one or more microphones for audio input.

[0092] Headsets can come in a variety of form factors or shapes. In some cases, headsets can be embodied as an earpiece that serves as the primary support mechanism for wearing the headset. For example the headset may be supported on the head by an earpiece worn over or in the ear. Alternatively, the headset may be supported by a frame or band that fits on or over the user's head. The headset may include a fixed or movable boom that places the microphone closer to the user's mouth (wraps around the face). Alternatively, the headset may be boomless such that the microphone is integrated with the earpiece thereby forming a more compact device (e.g., smaller, lighter, more aesthetically pleasing, etc.).

[0093] According to one aspect of the invention, the headset can be embodied as a small compact unit including a primary housing and an earbud member extending therefrom. The earbud member may be attached to or integrally formed with the primary housing. Various components can be placed at the surface of or within the confines of the earbud member and the primary housing. In fact, both of them can include one or more components depending on the needs of the device. The components contained within each of these can be widely varied. Examples of operational components can include speakers, microphones, antennas, connectors, buttons, displays, indicators, battery, and associated processors, controllers and circuitry. Generally, the earbud member includes at least a speaker while the primary housing includes at least a microphone (although this is not a requirement). Depending on their size, each of these members can include additional components of the headset. In one embodiment, the primary housing includes an antenna, user interface button, indicator or display (e.g., LEDs), battery, microphone, and/or a connector along with any accompanying circuitry while a speaker, a processor, and its accompanying circuitry can be located in the earbud. The button can be located on one end of the main housing. A user can interface with this button to perform various functions (e.g., terminating calls).

[0094] The shape and size and orientation of the earbud member and primary housing can be widely varied. In one embodiment, the earbud member is configured for insertion into the ear such that it supports the remaining portions of the headset (e.g., primary housing) proximate the user's head. In one embodiment, the primary housing can be configured as a longitudinal member (e.g., a tube). In one example, an earbud member, which contains a speaker, perpendicularly protrudes away from one end of a longitudinally extending primary housing, which includes a microphone at an opposite end of the longitudinally extending primary housing. Furthermore, the earbud member can expand outwardly and then inwardly from a neck portion that couples to the primary housing in order to form a bud that fits into an ear.

[0095] The primary housing can include a tube that forms a housing and receives internal components through an open end. The tube can be manufactured using one of several processes in order to reduce costs and increase speed and efficiency. In one embodiment, the tube can be manufactured to include features on the inner surface of the tube for supporting electronic components of the headset. Processes for creating such a tube can include applying a die and stamp to an extruded tube, single or double impact extrusion, or a progressive deep draw process.

[0096] The headset can include a hollow neck between the earbud and the primary housing in order to allow electrical wires to connect sets of discrete electronics disposed within the earbud and primary housing. In one embodiment, dual threaded inserts can be used to structurally reinforce the hollow neck without adding size to the device.

[0097] Small compact headsets have limited surface area for placing components. Therefore, one aspect of the invention relates to integrating multiple components into the same surface area of the headset in order to help form a small compact headset. Put another way, multiple components can be built into the same location on the headset in order to achieve the desired level of functionality without impacting a desired small size of the headset. The components may for example be selected from connectors, microphones, speakers, buttons, indicators, displays and/or the like. In one embodiment, an antenna and a button function at the same location of the headset. In another embodiment, a microphone and connector function at the same location of the headset. Other embodiments can also be realized. For example, a button can function at the same location of a speaker (e.g., at an earbud) or an indicator can function at the same location of a microphone.

[0098] Small compact headsets also have limited internal volume for placing internal components. Therefore one aspect of the invention relates to dividing/separating internal electronic assemblies into small multiple components that can be positioned at different locations (discretely) within the headset. By way of example, the electronics that would normally be embodied on a single large circuit board may be divided/separated out and placed on multiple smaller circuit boards, each of which can be positioned at different locations within the headset. The smaller circuit boards can be more easily placed within various small internal pockets found in a small compact device. Flexible wires and possibly wireless protocols can be used to operatively couple the electronics and/or discrete circuit boards together. In other words, a first portion of the electronics may be separated from a second portion of the electronics, and further the first portion may be positioned at a first location within the headset while the second portion may be positioned at a second location within the headset. Note that, two portions is not a limitation and the electronics can be divided into any number of smaller discrete portions.

[0099] Along a similar vein, another aspect of the invention relates to electronic assemblies that are partially flexible or bendable such that the assemblies can be folded into a small compact form in order to fit inside tightly spaced internal volumes. By way of example, the electronics that would normally be embodied on a single rigid circuit board may be placed on multiple rigid circuit boards that are interconnected by flexible or bendable circuit board portions that can be bent around various internal shapes and/or folded over itself while still functioning properly.

[0100] Another aspect of the invention relates to acoustical paths, ports and volumes that are built through a small compact headset in order to improve acoustical performance of the microphone and/or speaker (with limited impact on the form factor of the headset). In one embodiment, in order to control the flow of air through an earbud, acoustic ports can be integrated into one or more electronic components disposed therein and/or the earbud housing. In another embodiment, at least some of the ports that pass through the various housings are substantially hidden from view thereby enhancing the aesthetic appearance of the headset. For example, the ports may be positioned within a seam between two interfacing external surfaces of the headset. In one example, a first external surface is provided by the open end of a tube of the primary housing and the second external surface is provided by an end member disposed within the open end of the tube of the primary housing. The end member may for example include a connector assembly thereby integrating a connector with a microphone into the same surface area.

[0101] In accordance with one aspect of the invention, the connector assembly can include contacts for the transfer of power and data. The connector can be located on the end of the primary housing opposite a user interface button. The connector can have a symmetrical configuration so that it can be coupled with complementary connectors in more than one interface orientation (e.g., 90 degree symmetry, 180 degree symmetry, etc.). In one embodiment, switching circuitry can be included in order to accommodate this symmetry. Such circuitry can, for example, measure the polarity of data and/or power lines from the complementary connector to determine its interface orientation and route the data and/or power lines based on the determined orientation. In some embodiments, the connector assembly can be at least partially made of a ferromagnetic material, which can serve as an attraction plate for one or more magnets on a complementary connector in another device (e.g., a headset charger).

[0102] In accordance with another aspect of the invention, the headset can include an indicator that is hidden from view when inactive and that is in view when active. This can for example be accomplished with micrometer sized holes, called microperforations, that can be drilled into the wall of primary housing and/or earbud member. Through these holes, light sources on the inside of the primary housing and/or earbud member can create visual indicators for a user. A light diffuser can be used in combination with such microperforations so that the indicator can be illuminated with evenly distributed light.

[0103] Headsets may communicate with the host device via a wired and/or wireless connection. Wired connections may for example occur through a cable/connector arrangement.

Wireless connections on the other hand can occur through the air (no physical connection is needed). The wired and wireless protocols may be widely varied. Wired protocols may for example be based on Universal Serial Bus (USB) interfaces, Firewire interfaces, conventional serial interfaces, parallel interfaces, and/or the like. Wireless protocols may, for example, be based on short range transmissions of voice and/or data. The wireless protocols may further be used to create personal area networks between the headset and a nearby host device such as a cellular phone. Some examples of wireless protocols that can be used include Bluetooth, Home RF, iEEE 802.11, IrDA, Wireless USB, and the like. The communication electronics may be embodied as a system on a chip (SOC).

[0104] Although other wireless protocols may be used, according to one aspect of the invention, the headset can include communication electronics based on the Bluetooth wireless protocol. The communication electronics may, for example, include or correspond to a Bluetooth System-on-a-Chip (SoC). The SoC can include circuitry for performing functions other than wireless communications. For example, in some embodiments, circuitry for communicating using wired Universal Serial Bus (USB) interfaces and conventional serial interfaces can be integrated into the SoC.

[0105] For increased functionality, according to one aspect of the invention, the headset can include power distribution circuitry. Such circuitry can operate the headset according to several different modes depending, for example, on the charge level of the battery or the availability of an external power source. In one mode, the power distribution circuitry can supply power to limited parts of the SoC while simultaneously charging the battery. The battery charging process can be further improved by using temperature detection circuitry (e.g., a thermistor) to monitor the battery temperature. This process can extend the battery life by charging it only when the monitored temperature is at, or below, a predetermined threshold. In another mode, the power distribution circuitry can selectively power various electronic components using the battery while other electronic components may be powered by an external power source.

[0106] Aspects and embodiments of the invention are discussed below with reference to FIGS. **1-68**. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these figures is for explanatory purposes as the invention extends beyond these limited embodiments.

[0107] FIG. **1** is a simplified block diagram of headset **10** in accordance with one embodiment of the present invention. Headset **10** can be configured to be a small compact unit in the form of a simple earpiece that can be placed in the ear. The headset can include a primary housing **11** and an earbud **12** that extends from the primary housing. Earbud **12** can fit into an ear thereby placing the primary housing next to a user's face. Each of these members can surround and protect various internal components and can also support thereon various external components associated with operating the headset. The components may be a plurality of electrical components that provide specific functions for the electronic device. For example, the components may generally be associated with generating, receiving, and/or transmitting data associated with operating the device.

[0108] Headset **10** includes processor **20** for controlling the headset's functions. In the illustrated embodiment, processor **20** can be provided in earbud **12**. In other embodiments, processor **20** can be located anywhere in headset **10**. Processor **20** can be electrically coupled to the other components of headset **10** through circuit boards and/or cables. Processor **20** may facilitate wireless communications with a host device. For example, processor **20** can generate signals for wireless transmission and process received wireless signals. In addition to wireless communications, processor **20** may coordinate the operation of the various components of headset **10**. For example, processor **20** may control the charging of a battery or the operation of a display system.

[0109] Headset **10** also includes speaker system **13** for distributing audio information from earbud **12**. Speaker system **13** can include an audio port at the end of the earbud and a receiver (e.g., a speaker) disposed at the end of the audio port. The audio port may be covered with a grill. Speaker system **13** may also include various ports internal and external to the earbud. For example, speaker system **13** may include acoustical paths inside the earbud and acoustical paths that pass through the surfaces of the earbud.

[0110] Headset **10** also includes one or more input mechanisms for providing inputs to the headset. The input mechanism may be placed at the primary housing and/or the earbud. The input mechanisms may be widely varied and may include for example slide switches, depressible buttons, dials, wheels, navigation pads, touch pads, and/or the like. For simplicity purposes, the headset may only include a single input mechanism. Furthermore, for aesthetical reasons, the input mechanism may be placed at a select location. In other embodiments, two or more input mechanisms may reside on the headset.

[0111] In one embodiment, headset **10** includes single button **14** located at one end of primary housing **11**. Placing button **14** at the end preserves the side surfaces of primary housing **11**. This can also be accomplished by configuring earbud **12** as a button (e.g., the earbud is depressible relative to the primary housing). Earbud **12** may also be configured to tilt, rotate, bend and/or slide in order to provide inputs while preserving the side surfaces of primary housing **11**.

[0112] Headset **10** also includes a communication terminal for communicating with a host device. The communication terminal may be configured for wired or wireless connections. In the illustrated embodiment, the communication terminal is antenna **15** that supports wireless connections. Antenna **15** may be located internal to the primary housing or earbud. If the primary housing or earbud is not formed from a radio transparent material then a radio transparent window may need to be provided. In the illustrated embodiment, antenna **15** is located at one end of the headset. Placing antenna **15** and the accompanying radiotransparent window at the end preserves the side surfaces of primary housing **11**. In one embodiment, button **14** and antenna **15** are integrated at the same end.

[0113] Headset **10** may also include one or more connectors **16** for transferring data and/or power to and from the headset. A data connection allows data to be transmitted to and received from a host device. A power connection, on the other hand, allows power to be delivered to the headset. The connectors may for example connect to a corresponding connector in a dock or cable in order to connect to a power source for charging and/or a data source for downloads or uploads. Although the location of the connector can be widely varied, in the illustrated embodiment, connector **16** is located at one of the ends in order to preserve the side surfaces of the primary housing.

[0114] In some embodiments, connector **16** and corresponding connectors may be shaped such that the two connectors can mate in two or more different interface orientations. To compensate for this possibility, headset **10** can include switching circuitry that is coupled to connector **16**. Such switching circuitry can determine how connector **16** is coupled with a corresponding connector (e.g., how the connectors are physically orientated). Switching circuitry can determine this by measuring, for example, the polarity of data and/or power lines from the complementary connector. Switching circuitry can then route the data and/or power from the connector to other circuitry in headset **10** appropriately. In some embodiments, at least a portion of connector **16** can be magnetic or magnetically attractive. For example, connector **16** may include a ferromagnetic material that biases it to magnetic connectors. Such magnetic interactions can assist a user in coupling connector **16** with corresponding connectors and help prevent the connectors from uncoupling.

[0115] Headset **10** also includes microphone **17** for capturing speech provided by a user. The microphone is typically located internal to the primary housing. One or more acoustical ports may be configured into the primary housing in order to provide an acoustical path from outside the primary housing to the microphone. The location of the acoustical ports can be widely varied. In one embodiment, the acoustical ports are located at one end of the primary housing in order to preserve the sides of the primary housing. In one embodiment, the connector assembly and acoustical ports are integrated at the same end. Furthermore, the acoustical port may be configured to be substantially hidden from view by selective placement of the ports. For example, the ports may be placed at the seam between the connector assembly and the primary housing.

[0116] Headset **10** also includes display system **18** for providing visual feedback. The display system may be a complex display system comprising an LCD or other related display device capable of displaying graphical information and/or it may be an indicator assembly that only provides simple visual feedback as for example via an LED assembly. In one embodiment, the display system only comprises an indicator assembly that provides visual feedback along the side walls of the primary housing. In order to preserve the side walls, however, the indicator assembly may be hidden when inactive. This can be accomplished, for example, through microperforations through the primary housing. The microperforations allow light to pass through, but are so small that they are undetectable to a user.

[0117] Headset **10** also includes battery **19**. Battery **19** may provide electrical power to components of headset **10**. Charging circuitry may also be provided to charge battery **19** when an external power supply is connected to headset **10**.

[0118] Headset **10** can also include support circuitry for the aforementioned components. For example, this may include circuit boards, various electrical components, processors and controllers. The support circuitry can be placed inside the primary housing and/or the earbud. In one embodiment, the support circuitry can be split or divided between the two locations in order to make a more compact device, i.e., the various electronics are distributed among volumes as needed. In order to further save space, the electronics may be stackable. In one embodiment, the electronics are placed on a circuit board with one or more flexible portions so that a stack is created by folding or bending the circuit board.

[0119] Although earbud **12** and primary housing **11** can be integrally formed, in the illustrated embodiment, the primary housing and earbud are separate housing members that are attached together. Any suitable means can be used to attach the two parts together including but not limited to screws, glues, epoxies, clips, brackets, and/or the like.

[0120] The position of the earbud relative to the primary housing may be widely varied. For example, the earbud may be placed at any external surface (e.g., top, side, front, or back) of the primary housing. In one embodiment, the earbud is located on a planar front side near one of the ends of the primary housing. In one embodiment, the earbud may be configured to move relative to the primary housing so that its position can be adjusted.

[0121] Each of the earbud **12** and primary housing **11** can be configured to surround its internal components at a peripheral region thereof so as to cover and protect the internal components. They can also be configured to support components externally if needed. Each of earbud **12** and primary housing **11** help define the shape and form of the headset. That is, their contours embody the outward physical appearance of the headset. Such contours may be rectilinear, curvilinear or both. In one embodiment, earbud **12** is formed as an outwardly extending protruding member while primary housing **11** is formed as a longitudinally extending member. For example, earbud **12** may be coupled to primary housing **11** through a neck, which can be a portion of the primary housing, earbud or a separate piece altogether. The axis of earbud **12** and primary housing **11** can be transverse, and more particularly perpendicular. The shapes of earbud **12** and primary housing **11** may be widely varied. In one embodiment, earbud **12** is formed as a reverse rounded circular conical member and primary housing **11** is configured with a pill shaped cross section. It is understood however that these are not limitations and that the form, shape, and orientation may vary according to the specific needs or design of the headset. By way of example, earbud **12** and primary housing **11** may have various cross-sectional shapes including for example, circular, square, rectangular, triangular, oval, and/or the like. In addition, their form may be such that they do not have a typical straight axis.

[0122] Earbud **12** and primary housing **11** may be formed by one or more members. In one embodiment, primary housing **11** may include an integrally formed member. By integral, it is meant that the member is a single complete unit. By being integrally formed, the member can be structurally stronger than conventional housings, which include two parts that are fastened together. Furthermore, unlike conventional housings that have a seam between the two parts, the member has a substantially seamless appearance. Moreover, the seamless housing can prevent contamination and can be more water resistant than conventional housings. The primary housing may, for example, be formed as a tube that defines a cavity therethrough between a first open end and second open end located opposite the first open end. In order to seal the ends of the tube, the primary housing can additionally include a pair of end caps. Each of the end caps can be configured to cover one of the open ends thereby forming a fully-enclosed housing system. The end caps may be formed from similar or different materials as the tube. Furthermore, the end caps may be attached to the tube using a variety of techniques, including but not limited to, fasteners, glues, clips, brackets, and/or the like. The end caps can also be movably attached, and be configured to carry operational components of the headset.

[0123] It is understood that the inner cross-sectional shape of primary housing **11** may be the same or different from the external cross-sectional shape of the primary housing. For example, it may be desirable to have a pill shaped external and a rectangularly shaped interior, etc. In addition, although not a requirement, the front and back surface of primary housing **11** may be substantially planar.

[0124] In one embodiment, primary housing **11** can be formed via an extrusion or related process. The extrusion process is capable of producing an integral tube without seams, crack, breaks, etc. As is generally well known, extrusion is a shaping process where a continuous work piece is produced by forcing molten or hot material through a shaped orifice, i.e., the extrusion process produces a length of a particular cross-sectional shape. The cross-sectional shape of the work piece is controlled at least in part on the shaped orifice. As the shaped work piece exits the orifice, it is cooled and thereafter cut to a desired length. The extrusion process is a continuous high volume process that produces intricate profiles and that accurately controls work piece dimensions (which can be a necessity for smaller parts). Furthermore, because extrusion has low tooling costs, it is relatively inexpensive when compared to other forming or manufacturing processes.

[0125] Primary housing **11** may be formed from a variety of extrudable materials or material combinations including but not limited to metals, metal alloys, plastics, ceramics and/or the like. By way of example, the metals may correspond to aluminum, titanium, steel, copper, etc., the plastic materials may correspond to polycarbonate, ABS, nylon, etc, and the ceramic materials may correspond to alumina, zirconia, etc. Zirconia may, for example, correspond to zirconia oxide.

[0126] FIG. **2** shows headset connector system **200** in accordance with an embodiment of the present invention. System **200** can include headset **210** and headset engaging connector **220**. In some embodiments, headset **210** may correspond to headset **10** of FIG. **1**. Headset **210** can include any number of headset connector contact regions (see e.g., regions **211**, **212** and **213**) disposed within face **214** of the headset. Face **214** can mate with headset engaging connector **220** such that a corresponding number of headset engaging contact regions disposed in the headset engaging connector (see e.g., regions **221**, **222** and **223**) electrically couple with the headset connector contact regions. Moreover, headset **210** can include switching circuitry **215** that is electrically coupled with each of the headset connector contact regions. Switching circuitry **215** can be operative to determine an interface orientation between the headset connector contact regions and headset engaging contact regions. For example, switching circuitry **215** can determine the interface orientation in which headset **210** is mated with headset engaging connector **220**. Switching circuitry **215** can determine this by measuring the polarity of data and/or power lines from headset engaging connector **220**. After having determined the interface orientation, switching circuitry **215** can route signals received on the headset connector contact regions based on the determined orientation. It is understood that switching circuitry can be provided in connector **220** to provide functionality similar to switching circuitry **215**. For example, switching circuitry in connector **220** can determine the interface orientation of headset **210** and route electrical signals to contact regions based on the determined orientation.

[0127] In some embodiments, at least a portion of headset **210** and/or headset engaging connector **220** (e.g., a portion or all of housing **224**) can be magnetically attractive. Moreover, headset engaging contact regions (see e.g., regions **221**, **222**, and **223**) may be biased to protrude from housing **224** of connector **220**. In such embodiments, headset **210** can be magnetically attracted to headset engaging connector **220** such that the magnetic forces can cause the headset engaging contact regions (see e.g., regions **221**, **222**, and **223**) to press against the headset connector contact regions (see e.g., regions **211**, **212**, and **213**).

[0128] FIG. **3** shows electronic device **300** in accordance with an embodiment of the present invention. In some embodiments, device **300** may be an electronic headset (see e.g., headset **10** of FIG. **1**), but it is to be understood that device **300** is not limited to electronic headsets. Device **300** can include housing **310** and connector assembly **320**. At least a portion of connector assembly **320** may be disposed in housing **310**. Connector assembly **320** may include port **322**, microphone **324** and channel **326** that fluidically couples the microphone to the port. Connector assembly **320** may also include one or more contacts (see e.g., contacts **321**, **323**, **325** and **327**) for electrically coupling with another device. Port **322** may be provided in a location such that the contacts of connector assembly **320** are on the same exterior surface as the port or located nearby. In some embodiments, port **322** may be located between two contacts (see e.g., contacts **323** and **325**).

[0129] FIG. **4** shows electronic device **400** in accordance with another embodiment of the present invention. Like device **300**, device **400** may be an electronic headset in some embodiments (see e.g., headset **10** of FIG. **1**) but it is to be understood that device **400** is not limited to electronic headsets. Device **400** can include housing **410** and joint connector and microphone assembly **420**. Microphone **430**, boot **440** and connector plate **450** may be provided in joint connector and microphone assembly **420**. Microphone **430** may include one or more side surfaces and a top surface with microphone port **432**. Microphone boot **440** may be mounted to the microphone such that the boot forms a seal with at least a portion of the top surface and the side surfaces. This seal can surround microphone port **432**. Microphone boot **440** can further include a portion for sealing to connector plate **450** and an aperture for fluidically connecting microphone port **432** to connector port **452**. Connector plate **450** may include one or more contacts (see e.g., contacts **451**, **453**, **455** and **457**) for electrically coupling with another device. Connector port **452** may be provided in a location such that the port is in the same exterior surface as the contacts of connector assembly **420** or located near the contacts. In some embodiments, port **452** may be located between two contacts (see e.g., contacts **453** and **455**).

[0130] FIG. **5** shows headset **500** in accordance with an embodiment of the invention. Headset **500** may correspond to an electronic headset (see e.g., headset **10** of FIG. **1**) and may include primary housing **510** and earbud **520**. Primary housing **510** may correspond to primary housing **11** and earbud **520** may correspond to earbud **12**, for example. Earbud flexible circuit board **522** may be provided in earbud **520**. Receiver **524** and processing circuitry **526** can be mounted on the earbud flexible circuit board **522**. Earbud flexible circuit board **522** may be flexible such that it can fold upon itself or bend. Such flexibility may allow earbud flexible circuit board **522** to fit in smaller or less traditionally-shaped earbuds.

[0131] Primary housing **510** may be fixed to earbud **520**. Primary housing **510** may include primary housing flexible

circuit board **512** and microphone **514**. Like earbud flexible circuit board **522**, primary housing flexible circuit board **512** may be flexible such that it can fold upon itself or bend. Such flexibility may allow primary housing circuit board **512** to bend around other components in the primary housing (e.g., circuitry, antennas, or batteries) so as to conserve interior space inside the primary housing. For example, conserving interior space may result in more room to accommodate a larger battery. In another example, conserving interior space may result in a smaller primary housing. Earbud flexible circuit board **522** and microphone **514** can be electrically coupled to primary housing flexible circuit board **512**. In some embodiments, such as the one shown in FIG. **5**, earbud flexible circuit board **522** may extend into primary housing **510** such that it can couple with primary housing flexible circuit board **512**. In other embodiments, primary housing flexible circuit board **512** may extend into earbud **520** such that it can couple with earbud flexible circuit board **522**. It is to be understood that although primary housing flexible circuit board **512** and earbud flexible circuit board **522** are described as being flexible, one or both circuit boards may include both flexible and rigid portions. For example, each circuit board may include one or more rigid portions upon which electrical components (e.g., receiver **524**, processing circuitry **526**, or microphone **514**) can be easily and stably mounted.

[0132] FIG. **6**A shows headset device **600** in accordance with an embodiment of the present invention. Headset device **600** can include earbud housing **610**, threaded neck **620**, and primary housing **630**. Headset device **600** can correspond to headset **10** of FIG. **1** such that, for example, earbud housing **610** corresponds to earbud **12** and primary housing **630** corresponds to primary housing **11**. Earbud housing **610** can include earbud through-hole **612** and neck engaging surface **614**. Threaded neck **620** can include first neck surface **622** that can mate with the earbud housing's neck engaging surface **614**. First neck surface **622** and neck engaging surface **614** may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0133] Primary housing **630** can include primary housing through-hole **632** and neck engaging surface **634**. Threaded neck **620** can further include second neck surface **624** that can mate with the primary housing's neck engaging surface. Second neck surface **624** and neck engaging surface **634** may include one or more features (e.g., protrusions, tabs, slots or notches) such that they can only be coupled in a certain orientation (with respect to each other).

[0134] FIG. **6**B shows screw **690** for use with headset device **600** in accordance with the present invention. Screw **690** can be used as both an earbud screw and a primary housing screw. Screw **690** can include hollow channel **692** running through the center of the screw. Screw **690** may also include features **694** (e.g., notches) such that a tool can interface with the features and rotate the screw. As an earbud screw, screw **690** can be inserted into earbud through-hole **612** and tightened such that it fastens neck engaging surface **614** to first neck surface **622**. As a primary housing screw, screw **690** can be inserted into primary housing through-hole **632** and tightened such that it fastens neck engaging surface **634** to second neck surface **624**.

[0135] FIG. **7** shows display system **700** in accordance with an embodiment of the present invention. Display system **700** can, for example, correspond to display system **18** of FIG. **1**. System **700** can include housing **710**, light source **720**, diffuser **730** and control circuitry **740**. Housing **710** can have signal indicator region **712** disposed therein. Signal indicator region **712** may be, for example, one or more apertures (e.g., microperforations) for transmitting light. Signal indicator region **712** may be configured to output a signal of a certain shape or form. Housing **710** can also include internal wall **714**. Diffuser **730** can be located between light source **720** and internal wall **714**. Control circuitry **740** may be electrically coupled with light source **720** to control when light source **720** emits light.

[0136] Diffuser **730** may be operable to diffuse light from light source **720** such that all of the light exiting the diffuser has an equal intensity or brightness. For example, diffuser **730** may be operable to evenly illuminate signal indicator region **712** with the light from light source **720**. Diffuser **730** may be composed of a mixture of different particles that cause light diffusion. For example, diffuser **730** can include mainly clear particles with translucent particles distributed throughout. The translucent particles can cause light to be deflected from its original course so that the light is distributed throughout the diffuser. Accordingly, light exiting from any portion of the diffuser will have substantially even illumination.

[0137] FIG. **8** shows power distribution system **800** in accordance with an embodiment of the present invention. Power distribution system **800** can be employed in an electronic device (see e.g., headset **10** of FIG. **1**) and can include switch **810**, bus **820**, first power regulating circuitry **822**, core processing circuitry **824**, battery **830**, second power regulating circuitry **832**, RF processing circuitry **834**, and control circuitry **840**. Core processing circuitry **824** may include circuitry for handling low-level, core functions of the electronic device, and RF processing circuitry **834** may include circuitry for handling RF communications for the electronic device. To power core processing circuitry **824** and RF processing circuitry **834**, power distribution system **800** can include both bus **820** and battery **830** as potential power sources.

[0138] Bus **820** can be coupled to receive power from a source external to the system. For example, bus **820** may be coupled to a connector such that the bus can receive power through the connector. First power regulating circuitry **822** may be electrically coupled to bus **820** and core processing circuitry **824**. First power regulating circuitry **822** may be operable to, for example, convert power from bus **820** into a condition suitable for core processing circuitry **824** (e.g., by changing the voltage or regulating the current flow).

[0139] Battery **830** can be a device that stores chemical energy and makes it available in an electrical form. Battery **830** may be rechargeable. Second power regulating circuitry **832** may be electrically coupled to battery **830** and RF processing circuitry **834**. Second power regulating circuitry **832** may be operable to, for example, convert power from bus **820** into a condition suitable for core processing circuitry **824** (e.g., by changing the voltage or regulating the current flow).

[0140] Switch **810** may be electrically coupled to both core processing circuitry **824** and RF processing circuitry **834**. Switch **810** may be controlled by the presence of an external power source on bus **820**. For example, switch **810** may be activated when the voltage of bus **820** goes below a predetermined threshold. When switch **810** is activated, first power regulating circuitry **822**, core processing circuitry **824**, RF processing circuitry **834**, and second power regulating cir-

cuitry **832** may be electrically coupled such that both core processing circuitry and RF processing circuitry can share power.

[0141] Control circuitry **840** can be electrically coupled to bus **820**, first power regulating circuitry **822**, core processing circuitry **824**, and second power regulating circuitry **832**. Control circuitry **840** may be able to selectively active first power regulating circuitry **822** and second power regulating circuitry **832** based on bus **820**, core processing circuitry **824**, and/or any other signals in the electronic device.

[0142] FIG. **9** shows wireless headset **900** in accordance with an embodiment of the present invention. Headset **900** can be an electronic headset for communications (see e.g., headset **10** of FIG. **1**). Headset **900** can include processor circuitry **910** that has a first power consumption portion **912** and a second power consumption portion **914**. First power consumption portion **912** can, for example, include the core circuitry of an electronic device (e.g., boot-up circuitry), while second power consumption portion **914** can include the device's auxiliary circuitry (e.g., circuitry for RF communications). Headset **900** can further include power distribution circuitry **920**. Power distribution circuitry **920** can selectively power first power consumption portion **912** independent of whether second power consumption portion **914** is powered. In some embodiments, power distribution circuitry **920** can selectively power any combination of first power consumption portion **912** and second power consumption portion **914** based on one or more monitored conditions of headset **900**. For example, power distribution circuitry **920** can monitor if an external power source is present and/or the charge level of an internal battery in order to determine which power consumption portions to activate.

[0143] FIGS. **10**A and **10**B show perspective views of an illustrative headset in accordance with an embodiment of the present invention. Headset **1000** can correspond to headset **10** of FIG. **1**. For example, primary housing **1010** can correspond to primary housing **11** and earbud **1020** can correspond to earbud **12**.

[0144] Headset **1000** can include a housing that encloses the electronic and other elements of the headset. The housing can incorporate several pieces that are assembled using any suitable process (e.g., adhesive, screws, or press fit). In the example of FIGS. **10**A and **10**B, headset **1000** can include earbud **1020**, neck **1030**, primary housing **1010**, antenna cap **1011** and connector **1040**. Earbud **1020** can include perforations (e.g., acoustic ports) **1021** and **1022** for allowing air to pass into and out of the earbud **1020**. Front port **1021** can allow sound waves from a receiver located in earbud **1020** to reach a user's ear and/or the outside environment. Side ports **1022** can provide a path for acoustic pressure to vent to the outside environment. Earbud **1020** can be attached to primary housing **1010** by neck **1030**.

[0145] Attached to one end of primary housing **1010** is antenna cap **1011**. Antenna cap **1011** can have button **1012** disposed at least partially therethrough. A user can interface with button **1012** to control the headset. Primary housing **1010** can include display **1013** which can correspond to display system **700** of FIG. **7** or display system **18** of FIG. **1**. In some embodiments, display **1013** may include microperforations such as those discussed in more detail below in connection with FIGS. **48** and **49**. Located at the connector end of primary housing **1010**, connector **1040** includes at least one port (not shown in FIG. **10**A) for enabling a microphone inside housing **1010** to receive acoustic signals (e.g., a user's voice), and at least one contact **1042** for receiving power, data, or both from an external source. Connector **1040** may correspond to contact regions **211**, **212**, and **213** of FIG. **2**, for example.

[0146] Earbud **1020**, neck **1030**, primary housing **1010**, antenna cap **1011** and connector **1040** can be constructed from any suitable material including, for example, metal, plastic, silicone, rubber, foam, or combinations thereof. For example, earbud **1020** can be formed from a plastic element surrounded by a silicone seal and primary housing **1010** can be formed from aluminum. Earbud **1020**, neck **1030**, primary housing **1010**, antenna cap **1011** and connector **1040** can be manufactured using any suitable process (e.g., molding, casting or extrusion). In some embodiments, earbud **1020**, neck **1030**, primary housing **1010**, antenna cap **1011** and connector **1040** can be post processed to provide texture and other features on the inner or outer surfaces of the bodies. For example, a bead blast and anodization process can be used to apply a desired surface texture to primary housing **1010**.

[0147] FIG. **11**A is an exploded view of headset **1100** in accordance with an embodiment of the present invention. Headset **1100** can correspond to headset **10** of FIG. **1** or headset **1000** of FIGS. **10**A and **10**B, for example. In one embodiment of the present invention, earbud housing **1120** can contain earbud circuit board **1122**. Earbud circuit board **1122** can, for example, correspond to earbud circuit board **522** of FIG. **5**. Earbud circuit board **1122** can be a flexible circuit board on which one or more of the following components are electrically and/or mechanically mounted: processor **1123** (which can be used to control the functions of headset **1100**), receiver **1124**, and other circuitry and components. The flexible nature of earbud circuit board **1122** can enable it to be folded onto itself, providing layers of circuitry that can be packed into earbud housing **1120**, thereby occupying space within earbud housing **1120** that may otherwise be empty and unused. The flexible portions of earbud circuit board **1122** can replace the need for separate wires connecting different circuit boards, which might cause a substantial increase in size because, for example, each wire might involve a pair of connectors. Additionally, the flexible nature of circuit board **1122** can advantageously reduce the area or footprint required by circuit board **1122**. That is, compared to another circuit board having similar circuitry and components disposed thereon but in an unfolded layout, circuit board **1122** can occupy less area. In addition, circuit board **1122** further can reduce the footprint or size requirements of other components of headset **1100**, such as primary housing **1110** and antenna cap **1111**, by incorporating within earbud housing **1120** electronics and other components that traditionally are located elsewhere within a headset. Earbud housing **1120** and the circuitry and components contained therein are discussed in more detail below in connection with FIGS. **18**-**27**B, for example.

[0148] Earbud housing **1120** can be coupled to primary housing **1110** by neck **1130**. Earbud housing **1120**, primary housing **1110**, and neck **1130** can correspond, respectively, to earbud housing **610**, primary housing **630**, and neck **620** of FIG. **6**. Neck **1130** can be constructed with a double threaded screw insert to receive screw member **1131** (associated with earbud housing **1120**) and screw member **1132** (associated with primary housing **1110**). Neck **1130** can connect earbud housing **1120** and primary housing **1110** in a manner that can reduce the likelihood of earbud housing **1120** and primary housing **1110** rotating independently of each other. That is,

when headset **1100** is in use and the user adjusts its position by, for example, pulling primary housing **1110** down, the earbud housing **1120** can rotate in conjunction with primary housing **1110**. However, in some embodiments, pulling primary housing **1110** down may cause the housing to rotate with respect to earbud housing **1120** so as to trigger a switch and signify a user input. A more detailed discussion of headset necks and their assembly can be found below in connection with FIGS. **28-30**, for example.

[0149] In addition to earbud circuit board **1122**, headset **1100** also can include primary housing circuit board **1115** on which additional electronic components **1113** can be electrically and/or mechanically mounted. Primary housing circuit board **1115** may, for example, correspond to primary housing circuit **512** of FIG. **5**. Primary housing circuit board **1115** can be electrically coupled with the earbud circuit board by one or more wires, cables, flexible circuit boards, and the like. The arrangement of electronic components in both earbud circuit board **1122** and primary housing circuit board **1115** can advantageously reduce the size of headset **1100**. The arrangement of the electronic components in headset **1100** will be discussed in more detail below in connection with FIGS. **18-20**C, for example.

[0150] A user can control the functions of headset **1100** using button **1112**, which can be electrically coupled with primary housing circuit board **1115**. Button **1112** can extend from antenna cap **1111** such that it appears as a discrete user interface easily activated by a user. Button **1112** can be configured to move in any suitable manner including, for example, bending with respect to primary housing **1110**, translating in and out of antenna cap **1111**, rotating around an axis passing through connector plate **1141** and button **1112**, or any combination thereof.

[0151] In one embodiment, button **1112** can include a switch such as a dome switch, which can be activated when a user depresses button **1112**. Button **1112** can have a button guide structure. The button guide structure can have one or more guide channels to facilitate user actuation of the button with respect to the rest of headset **1100**. In one embodiment of the present invention, the guide channel(s) can be provided in the form of a hole through the button guide structure. The switch actuation member can have a stem that is supported and guided by the guide channel. When pressed by a user, the switch actuation member moves along the guide channel towards the switch. Raised structures (e.g., ribs) can be used to ensure that the switch actuation member reciprocates smoothly within the guide channel.

[0152] Button **1112** and antenna cap **1111** can be constructed from a dielectric material such as plastic. Antenna **1118** can be formed by mounting an antenna resonating element within antenna cap **1111** (e.g., along an inner surface of antenna cap **1111**) or on a portion of the button guide structure. Constructing button **1112** and antenna cap **1111** from a dielectric material can reduce or eliminate potential signal interference that can disrupt the proper operation of antenna **1118**. In addition, a dielectric button **1112** can allow for smaller clearance between the antenna resonating element and conductive structures (e.g., primary housing circuit board **1115**) in headset **1100**.

[0153] Antenna **1118** can be electrically coupled with primary housing circuit board **1115** so that it can send and receive wireless (e.g., radio) signals. Antenna **1118** can include any suitable antenna resonating element for communicating between headset **1100** and an electronic device (e.g., a cellular telephone or a personal media device). The antenna resonating element can be formed from a flex circuit containing a strip of conductor. The flex circuit can be attached to the button guide structure using, e.g., adhesive. For example, the flex circuit can contain registration holes that mate with corresponding registration bosses on the button guide structure. One or more of the bosses can be heat staked to the flex circuit.

[0154] Details about the operation and design of an antenna and button system similar to antenna **1118** and button **1112** can be found, e.g., in U.S. patent application Ser. No. 11/651,094 entitled "Antenna and Button Assembly for Wireless Devices," which is incorporated herein.

[0155] Appendages **1117** can be incorporated into antenna cap **1111** in order to mount the antenna cap to headset **1100**. Appendages **1117** can, for example, fasten to primary housing **1110** or one or more brackets **1116** which will be discussed in more detail below.

[0156] Battery pack **1119** can be located within primary housing **1110**. Battery pack **1119** can contain one or more suitable batteries including, for example, lithium ion, lithium ion polymer (Li-Poly), nickel metal hydride, or any other type of battery. Battery pack **1119** can be electrically coupled with circuit board **1115** for powering electronic components in headset **1100**. Additionally, circuitry that is typically packaged within standard battery packs (e.g., charging or fuse protection circuitry) can be moved to primary housing circuit board **1115**. Advantageously, the distribution of circuitry into earbud housing **1120** and the layout of circuit board **1115** can permit battery pack **1119** to occupy a substantial portion of the internal space of primary housing **1110**. This can increase the energy storage capacity of headset **1100** (e.g., allow headset **1100** to operate for longer period of time in between charges) without increasing the size of primary housing **1110** and headset **1100**.

[0157] Headset **1100** can include connector **1140** for enabling headset **1100** to electrically connect to other devices. An opening or port can be included in connector **1140** so that acoustic signals (e.g., speech from a user) can reach the microphone inside microphone boot **1144**. Connector **1140** can, for example, correspond to assembly **320** of FIG. **3** or assembly **420** of FIG. **4**, for example. The microphone can be electrically coupled with circuit board **1115** in any suitable manner. Microphone boot **1144** can be placed inside the end of primary housing **1110** that is farthest from earbud housing **1120**. This end may be referred to herein as the microphone or connector end of headset **1100**, and is also the portion of headset **1100** that is closest to the user's mouth when in use. The arrangement of the microphone boot **1144** with respect to connector **1140** and accompanying parts is discussed in more detail below in connection with the description accompanying FIGS. **50**A-**54**.

[0158] Connector **1140** can include connector plate **1141** in which contacts **1142** and accompanying casing **1143** can reside. As such, contacts **1142** can facilitate the electrical coupling of headset **1100** with another device. Accompanying casing **1143** can be made from a non-conductive material (e.g., a polymeric material). Casing **1143** can surround contacts **1142** to prevent the contacts from electrically coupling with connector plate **1141**. Contacts **1142** and casing **1143** can be substantially flush with the surface of connector plate **1141** so that the combination of the contacts, casing and plate creates a substantially flat surface for mating with other connectors. Connector plate **1141** can be made of a ferromagnetic material so that it is biased to magnetic connectors, such as

those discussed in connection with FIGS. **62**A-**67**B, for example. The design of connector plate **1141**, contacts **1142**, casing **1143** and complementary magnetic connectors will be described in more detail below in connection with the discussion of FIGS. **55**A-**67**B.

[0159] Headset **1100** can include one or more brackets **1116** to couple connector **1140** with appendages **1117** of antenna cap **1111**. Brackets **1116** can prevent connector plate **1141** and antenna cap **1111** from moving axially away from each other or separating from primary housing **1110**. Alternatively, connector plate **1141** and antenna cap **1111** can be coupled to one or more brackets that are secured to the inner surface of primary housing **1110**.

[0160] As a matter of design choice, a seam can be included in between the peripheral surface of connector plate **1141** and the inner surface of primary housing **1110**. That is, in addition to the predefined port for providing an acoustic pathway between the microphone and the outside environment, gaps can exist. These gaps can advantageously enable the microphone to receive acoustic signals in the event the predefined acoustic pathway is blocked (e.g., by a foreign object such as dirt). In other embodiments, an adhesive may be applied to provide a substantially airtight seal between connector plate **1141** and primary housing **1110**. In yet another embodiment, a gasket may be used to provide a seal.

[0161] FIG. **12** shows a view of headset **1200** in accordance with another embodiment of the present invention. Headset **1200** can be similar to headset **1100**, but with some substantial differences between the two. For example, headset **1200** can use a different attachment technique to couple connector **1240** to primary housing **1210**. Connector **1240** can include tabs **1242** which can be used to couple with features (e.g., wall **1212**.) on an interior surface of primary housing **1210**. Such a method might be advantageous to using the brackets **1116** in headset **1100**. For example, the tabs **1242** can attach to the near end of primary housing **1210** which might provide connector **1240** with higher structural integrity than, for example, the method of using brackets to attach to a structure (e.g., antenna cap) on the other end of the primary housing. Headset **1200** can also include light diffuser **1244** which can be used in conjunction with a visual indicator system as discussed in connection with FIGS. **48** and **49**. Additionally, headset **1200** can include antenna **1218** which can wrap around button guide **1217** in some embodiments.

[0162] The fundamental basics of the Bluetooth protocol are well known in the art, and discussed briefly below. For a more detailed discussion, please see Bluetooth Specification Version 2.0+EDR, Vol. 0, Nov. 4, 2004, which is hereby incorporated by reference in its entirety. Bluetooth wireless technology is based on an international, open standard for allowing intelligent devices to communicate with each other through wireless, low power, short-range communications. This technology allows any sort of electronic equipment, from computers and cell phones to keyboards and headphones, to make its own connections, without wires or any direct action from a user. Bluetooth is incorporated into numerous commercial products including laptop computers, PDAS, cell phones and printers, and is likely to be used in future products.

[0163] Bluetooth can be referred to as a frequency hopping spread spectrum (FHSS) radio system that operates in the 2.4 GHz unlicensed band. Bluetooth transmissions change frequencies based on a sequence which is known to both the transmitter and the receiver. According to one known standard, Bluetooth transmissions use **79** different frequencies ranging from 2.404 GHZ to 2.480 GHZ. Bluetooth's low power transmissions allow a typical range of about 10 meters or roughly 30-40 feet. This range can vary from about 1 meter to 100 meters depending on the amount of power used by the device for Bluetooth transmissions.

[0164] Bluetooth devices connect to each other to form networks known as piconets. A piconet includes two or more devices which are synchronized to a common clock signal and hopping sequence. Thus, for any device to connect to a given piconet, that device may need to have the same clock signal and hopping sequence. The synchronized clock and hopping sequence can be derived using the clock signal of one of the devices on the piconet. This device is often referred to as the "master" device while all other devices on the piconet are referred to as "slave" devices. Each piconet can include one master device and up to seven or more slave devices. Moreover, Bluetooth devices can belong to more than one piconet. The term "scatternet" is used to define Bluetooth networks which are made up of multiple, overlapping piconets. In the case where one Bluetooth device is on two or more piconets, all of the devices are on a single scatternet. Devices from one of the piconets can communicate with devices from another piconet by using the shared device to relay the signals.

[0165] When two Bluetooth devices initially connect, they first share some general information (e.g., device name, device type) with each other. In order to enhance the connection, the devices can establish a trusted relationship by using a secret passkey. This passkey is typically provided by a user or stored on memory in a device. According to a known Bluetooth standard, the process of establishing this trusted relationship is called pairing. Once two devices are paired, they typically share information and accept instructions from one another.

[0166] Bluetooth devices can operate with a maximum data throughput of approximately 2.1 Mbit/s (Megabits-per-second), but it is understood that such limitations change as technology advances, and that embodiments of the present invention may operate at other rates. This maximum throughput is shared among all devices on a piconet, meaning that if more than one slave device is communicating with the master, the sum of all communications is less than the maximum data throughput.

[0167] The Bluetooth standard includes a published software framework. The shared framework is called the Bluetooth Protocol Stack and includes different software applications to implement Bluetooth communications. FIG. **13** is a simplified schematic diagram of an exemplary Bluetooth Protocol Stack **1300** in accordance with an embodiment of the present invention. Low-level software is included in Lower Stack **1302**. This section includes code to generate/receive radio signals, correct transmission errors and encrypt/decrypt transmissions, among other things. The Host Controller Interface (HCI) **1304** is a standardized interface between the low-level Bluetooth functions and applications. The HCI layer represents a division between the Lower Stack **1302** functions handled by a dedicated Bluetooth processor and the rest of the functions handled by an application-specific processor.

[0168] The Extended Synchronous Connection-Oriented (eSCO) **1306** layer is used to implement dedicated communication channels, commonly used for voice data, in between the Lower Stack **1302** and high-level applications. The Logical Link Control and Adaptation Protocol (L2CAP) **1308**

layer combines and repackages the data transmitted and received by the multiple higher-level applications. The L2CAP **1308** layer combines all of these different communications into one data stream that can interface with Lower Stack **1302** The RFCOMM **1310** layer emulates the protocol used by serial connections. This allows software designers to easily integrate Bluetooth into existing applications which previously used a serial connection. The Service Discovery Protocol (SDP) **1312** layer is used by devices to provide information about what services (or functions) each device offers and how other devices can access those services through Bluetooth.

[0169] The Profiles **1314** layer allows a device to identify itself as a member of a generic group of devices with a predefined set of functions. For example, a device complying with the headset profile may support predefined methods relating to audio communications. The Application Layer **1316** contains programs that implement the useful tools created by all of the other layers. By writing different programs for Application Layer **1316**, software developers can focus on new uses of the Bluetooth functionality without having to rewrite the code which controls the underlying communication tasks.

[0170] FIG. **14** shows a simplified block diagram of exemplary electronic system **1400** of a headset in accordance with an embodiment of the present invention. The system of **1400** can be implemented in, for example, headset **10** of FIG. **1** or headset **1000** of FIGS. **10**A and **10**B. System **1400** can include processor circuitry **1410**, interface circuitry **1420**, power distribution circuitry **1430**, switching circuitry **1440** and 4-pin symmetrical magnetic connector **1455**.

[0171] Processor circuitry **1410** can include processor **1411** and auxiliary circuitry that operates in connection with processor **1411**. Processor **1411** can coordinate all of the operations in system **1400**, including, for example, Bluetooth transmissions, battery charging and processing (e.g., encoding and decoding) of acoustic signals. Processor **1411** can drive receiver **1412** to provide acoustic signals that may be heard by a user. Reset circuit **1413** can detect when system **1400** is connected to another device and subsequently instruct processor **1411** to reset. Power FET **1414** can be used with the power supply circuitry inside processor **1411** and will be discussed in more detail below in connection with the discussion of FIG. **15**. Antenna **1415** can be used to send wireless signals to and receive wireless signals from another device (e.g., a phone or portable media device). UART multiplexer **1416** can be electrically coupled with processor **1411** and can route data signals to different parts of processor **1411**. This routing can reduce unwanted effects, such as inductance, in unused data lines.

[0172] Interface circuitry **1420** can include a microphone isolation LDO **1421**, a micro-electro-mechanical (MEMs) microphone **1422**, LED driver **1424** and switch **1423**. Microphone isolation LDO **1421** can be electrically coupled with MEMs microphone **1422**. Microphone isolation techniques and MEMs microphones are well known, and a person of ordinary skill in the art will appreciate that these elements can be replaced by other equivalent microphone configurations without deviating from the spirit of the present invention. LED driver **1424** can be configured to drive a LED display unit based on one or more outputs of processor **1411**. Details about the design and function of circuitry similar to LED driver **1424** can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein. Switch **1423** can represent the electrical behavior of button **1012** of FIG. **10**B. A user can interface with this switch to input commands to the headset. For example, a user can depress switch **1423** to initiate a telephone call, terminate a call, or both. In one embodiment, switch **1423** can be a single-pole, single-throw switch with a spring to bias it to an open position.

[0173] Power distribution circuitry **1430** can include over-voltage protection and fuse **1431**, battery protection circuitry **1432** and thermistor **1433**. Over-voltage protection and fuse **1431** can protect system **1400** in the event that an unsafe amount of voltage is applied to one or more inputs. The fuse in the protection circuitry can be an over-current protection device which disconnects the inputs of the headset if an over-current condition is detected. Battery protection circuitry **1432** can include circuitry to prevent the malfunction of a battery (e.g., a li-poly battery) which could result in a dangerous overheating situation. Battery protection circuitry **1432**, in contrast to conventional headsets which has such circuitry integrated into the battery pack, can be separated from the battery pack and located elsewhere within a headset according to the invention. Thermistor **1433** can be located in the proximity of a battery (see e.g., battery pack **1119** of FIG. **11**) and may change its resistance based on the battery's temperature. One or more inputs of processor **1411** can be electrically coupled with thermistor **1433** to monitor the temperature of the battery. Processor **1411** can be programmed to charge the battery differently depending on the detected battery temperature. For example, processor **1411** may charge the battery at a faster rate when the monitored battery temperature is low than when the temperature is high. By regulating the charging in this manner, the time required to completely charge a battery can be decreased without damaging the battery.

[0174] Symmetrical magnetic connector **1455** can allow system **1400** to connect to other devices and systems for communicating data or transmitting power. Connector **1455** represents the electrical behavior of connector **16** of FIG. **1**, for example.

[0175] Switching circuitry **1440** can enable connector **1455** to connect and communicate with many different types of devices and in many interface orientations. Switching circuitry **1440** can, for example, correspond to switching circuitry **215** of FIG. **2**. Switching circuitry **1440** can include power polarity switch circuit **1441** and data polarity switch circuit **1442**. The two circuits can, for example, determine the type of communication interface being used and route the corresponding data and/or power lines to the correct pathways (e.g. internal electrical traces) for the detected interface. The two circuits can also determine the interface orientation of a connection with another device, for example, and route the corresponding data and/or power lines to the correct pathways (e.g., internal electrical traces) for the detected orientation. A detailed description of the design and function of exemplary circuits similar to switch circuits **1441** and **1442** can be found in U.S. patent application Ser. No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein.

[0176] FIG. **15** shows processor **1500** which can be used as the core processor or application processor of a headset in accordance with an embodiment of the present invention. Processor **1500** can, for example, correspond to processor **20**

of FIG. **1**. Processor **1500** can also be referred to as a System on a Chip (SoC) because it can be a single integrated circuit capable of a diverse range of functions. Processor **1500** can be a CSR BC04 Audio Processor with integrated Flash Memory that fully supports the Bluetooth v2.0+EDR specification. An oscillator **1510** and clock generation circuitry **1511** can be used in conjunction with a timing crystal to establish a timing signal (or clock) which processor **1500** can use to coordinate its activities. RF circuitry **1520** can be used to input and output RF signals for wireless communications. Baseband circuitry **1530** can coordinate communications so that they conform with the a communications protocol (e.g., a Bluetooth protocol). Flash memory **1531** can store, for example, software and configuration information for processor **1500**. Random access memory (RAM) **1532** can temporarily store data for Baseband circuitry **1530** and microprocessor **1533**. RISC microprocessor **1533** can be programmed to perform various functions, such as monitoring a thermistor (see e.g., thermistor **1433** of FIG. **14**) and coordinating battery charging as previously described, for example.

[0177] Full speed USB controller **1540** and UART circuitry **1541** can facilitate wired communication interfaces so that processor **1500** can share data with another device through a physical interface (e.g., connector contacts **1042** of FIG. **10**A). In one embodiment, processor **1500** can support both full speed USB and simplified RS-232 serial interfaces. A simplified RS-232 interface can include, for example, three lines: transmit data, receive data, and ground. In order to accommodate more than one interface over a limited number of data lines, USB controller **1540** and UART circuitry **1541** can be coupled to a switch (e.g., UART Multiplexer **1416** of FIG. **14**). This switch can route data lines to the circuitry, within processor **1500**, that corresponds to the communication interface being used. A more detailed discussion of similar systems and methods for using more than one communications interface over a limited number of data lines can be found in U.S. patent application Ser. No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein. Processor **1500** can also support other interfaces in addition to those discussed above without deviating from the spirit of the present invention. For example, processor **1500** can include circuitry for supporting a proprietary communications interface.

[0178] Processor **1500** can include differential microphone input amplifier **1551** and differential speaker output amplifier **1552**. Both the input amplifier **1551** and the output amplifier **1552** can be electrically coupled with Audio CODEC **1550** to process (e.g., encode and decode) audio signals. Power control and regulation circuitry **1560** can include low-dropout regulator (LDO) **1561**, battery charger **1562** and switch mode power supply (SMPS) **1563**. The power needed for the various subsystems of processor **1500** can be regulated by LDO **1561** or SMPS **1563** depending on both the charge level of the battery and any external power sources that might be connected. This will be described in more detail below in connection with the discussion of FIG. **16**. Battery charger **1562** can output a controllable current between 25 and 100 milliamps to charge a battery (see e.g., battery pack **1119** of FIG. **11**). In accordance with an embodiment of the present invention, this controllable current can vary based on various factors (e.g., the detected temperature of the battery).

[0179] Programmable I/O **1570** can include LED driver **1571** and analog-to-digital converter (ADC) **1572**. LED driver **1571** can use signals from other circuitry in processor **1500** to generate signals with sufficient current to illuminate one or more indicator LEDs. The design and operation of exemplary circuitry similar to LED driver **1571** can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein. Analog-to-Digital Converter (ADC) **1572** can accept inputs from analog circuitry and convert them to digital signals to be used by other circuitry in processor **1500**. For example, ADC **1572** can monitor the current running through a thermistor (see e.g., thermistor **1433** of FIG. **14**) to determine the temperature of a battery. Circuitry in processor **1500** can use this temperature information to determine an appropriate charging current for battery charger **1562** to provide. Moreover, it is understood that ADC **1572** can process multiple analog signals concurrently. For example, in addition to the temperature information above, ADC **1572** can also process voltage information about the current charge level of a headset's battery.

[0180] While the processor described above and shown in FIG. **15** is a CSR BC04 Audio Processor, other processors with other configurations and functionality can be used in a headset without deviating from the spirit of the present invention.

[0181] FIG. **16** shows a simplified schematic of power distribution system **1600** for the subsystems of processor **1605** in accordance with an embodiment of the present invention. System **1600** can, for example, correspond to system **800** of FIG. **8** and headset **900** of FIG. **8**. Moreover, processor **1605** can correspond to processor **1500** of FIG. **15**. Processor **1605** can include both low-dropout regulator (LDO) **1620** and switch mode power supply (SMPS) **1625** as options for regulating power for processor **1605**. SMPS **1625** can output power with a higher efficiency than LDO **1620**, but can require the installation of several additional components, such as a relatively large capacitor and inductor, which can increase the cost (and size) of system **1600**. In addition, SMPS **1625** may require an input voltage that meets, or exceeds, a predetermined voltage level to operate. Therefore, it may be a matter of design choice as to which power supply is used. For example, in low voltage applications, it may be advantageous to use LDO **1620**. In other embodiments, such as the one shown in FIG. **16**, LDO **1620** and SMPS **1625** can both be used to provide functionality over a wide range of input voltages and high power efficiency.

[0182] FIG. **16** shows processor **1605** which includes core circuitry **1610** and radio circuitry **1615** in accordance with an embodiment of the present invention. Radio circuitry **1615** can include, for example, circuitry related to RF communications. Additional functions (e.g., low-level system functions, firmware updates) can be executed by core circuitry **1610**. Additionally, core circuitry **1610** can monitor and control other circuitry in system **1600** using, for example, input line **1614** and output lines **1611**, **1612** and **1613**.

[0183] Power distribution system **1600** can include circuitry for interfacing with two power sources. In FIG. **16**, an internal battery is represented by BAT **1655**, and an external power supply is represented as BUS **1650**. From herein, the voltage of BAT **1655** will be referred to as VBAT. BUS **1650** can, for example, represent the power provided by a battery charger that is connected to system **1600**. BUS **1650** can be electrically coupled with LDO **1620** such that the LDO draws power from an external source through BUS. Therefore, LDO **1620** operates when an external power supply is connected to

system **1600**. Similarly, SMPS **1625** can be electrically coupled with BAT **1655** so that it draws power from the battery.

[0184] Other circuitry in power distribution system **1600** can include Power FET **1640**, Analog-to-Digital Converter (ADC) **1630** and logic gates **1661**, **1631** and **1632**. Button **1660** can represent, for example, a signal from an on/off switch or other circuitry that can signal processor **1605**.

[0185] An illustrative operation of system **1600**, in which BAT **1655** is the only source of power, is now discussed. An absence of power on BUS **1650** prevents LDO **1620** from supplying power and causes FET **1640** to turn on, thereby effectively coupling nodes **1641** and **1642**. System **1600** may be turned on when button **1660** is activated and outputs a high voltage. Activation of button **1660** can cause the button input of gate **1661** to go HIGH, which can cause the output of the gate **1661** to go HIGH. This HIGH signal can cause gate **1632** to assert a HIGH signal on its output. When gate **1632** outputs a high voltage, SMPS **1625** is activated and can begin providing power, if VBAT is at or above the predetermined voltage level (e.g., BAT **1655** has sufficient power to run SMPS **1625**). Because power FET **1640** is on, the power provided by SMPS **1625** can be transmitted to radio circuitry **1615** and core circuitry **1610**. As core circuitry **1610** begins to boot up, it can output a HIGH signal on line **1613** so that gate **1632** continues to output a HIGH signal after button **1660** is released. System **1600** can operate with full functionality at this point because both core circuitry **1610** and radio circuitry **1615** are receiving power. However, when VBAT drops below the predetermined voltage level (e.g., BAT **1655** is dead), SMPS may no longer be able to produce reliable power and system **1600** may begin to shut down.

[0186] An illustrative operation of system **1600** receiving power from an external power source on BUS **1650** is now discussed. The power on BUS **1650** can provide supply power to LDO **1620** and cause power FET **1640** to turn OFF or remain turned OFF, effectively decoupling nodes **1641** and **1642**. Additionally, the power on BUS **1650** can cause gates **1661**, **1631** and **1632** to output HIGH signals. When gate **1631** generates a HIGH signal, LDO **1620** can begin supplying power. Power from LDO **1620** may be provided to core circuitry **1610**, but not to radio circuitry **1615**, because power FET **1640** is not conducting. When core circuitry **1610** receives power, it can output a HIGH signal on line **1611** which causes the output of gate **1631** to maintain a HIGH signal so that LDO **1620** can continue operating.

[0187] SMPS **1625** may not be able to operate until VBAT has risen to or above the predetermined voltage level. Core circuitry **1610** can instruct battery charging circuitry (not shown) to begin using power from BUS **1650** to charge BAT **1655**. Core circuitry **1610** can receive signals (e.g., digital signals) from ADC **1630** over line **1614**. ADC **1630** can be electrically coupled with BAT **1655**. ADC **1630** can convert a signal with a varying voltage (e.g., VBAT) into a digital signal that can be processed by core circuitry **1610**. When VBAT has met or exceeded the predetermined voltage level, SMPS **1625** may now be able to operate and provide radio circuitry **1615** with power. Note that in some embodiments, SMPS **1625** may be powered ON substantially immediately when an external power service is connected to BUS **1650**. Using ADC **1630**, core circuitry **1610** can detect when SMPS turns on and coordinate the functions of processor **1605** accordingly. For example, when radio circuitry **1615** is powered, core circuitry **1610** can begin sending communications data to radio circuitry **1615**. In this manner, processor **1605** can operate with full functionality before BAT **1655** is fully charged.

[0188] While BAT **1655** is charging, core circuitry **1610** can perform various other functions, regardless of whether VBAT has met or exceeded the predetermined voltage level. For example, core circuitry **1610** can run boot up processes, communicate over wired interfaces and run user interfaces. In this manner, core circuitry **1610** can, for example, handle auxiliary processes (e.g., downloading firmware updates via a wired interface and installing the updates) before processor **1605** has full functionality.

[0189] Several benefits may be realized by power distribution system **1600** in the manner discussed above. For example, the core circuitry **1610** can turn ON before the battery has reached a minimum charge threshold. This enables core circuitry **1610** to handle boot up processes in advance, thereby enabling headset to begin working immediately once the battery is charged to the minimum level. In effect, certain components may be powered independent of BAT **1655** when an external power supply is connected to BUS **1650**.

[0190] Additionally, system **1600** limits the unnecessary use of BAT **1655**. Traditionally, known headset circuitry is powered through a battery even if an external power supply is present. The power drained from the battery is then recharged using power from the external power supply. This charging and recharging can shorten a battery's lifespan. System **1600** allows core circuitry **1610** to draw power independent of BAT **1655** and directly from an external supply (if present), extending the life of BAT **1655**.

[0191] To provide additional functionality, output line **1612** can be included in core circuitry **1610** so that the core circuitry can shut down system **1600**. Line **1612** can be coupled with node **1633** such that line **1612** can drive node **1633** to a LOW signal. Therefore, if core circuitry outputs LOW signals to lines **1611**, **1612** and **1613**, the output of gates **1631** and **1632** go LOW, turning off both LDO **1620** and SMPS **1625**, which causes core circuitry **1610** and radio circuitry **1615** to turn off.

[0192] While the previous discussion described a method and system for separately powering on core and RF radio circuitries, the same techniques can be applied to other electronic subsystems which, for example, might be unrelated to RF communications.

[0193] FIGS. **17A-17C** show different views of known headset circuit boards, with particular emphasis on how circuitry and components are distributed therein. Electrical components **1796**, including processor **1792**, may be mounted on two sides of circuit board **1790**. As can be appreciated by one of skill in the art, circuit board **1790** may occupy a relatively large, undistributed area. Such circuit boards can limit the amount that other components (e.g., batteries, buttons, antennas) are spatially integrated with the electronics. Thus, known headsets have to be relatively large to accommodate such boards and other components.

[0194] FIG. **18** is a simplified schematic system diagram of a headset showing a circuit board arrangement in accordance with an embodiment of the present invention. System **1800** can correspond to headset **500** of FIG. **5**, for example. System **1800** can be divided into two independent and separately arranged circuit boards **1810** and **1820**. That is, when boards **1810** and **1820** are installed in a headset according to an embodiment of the present invention, the boards may be electronically coupled to each other, but the boards them-

selves are discrete. Circuit board **1810** corresponds to earbud circuit board **522** of FIG. **5** and earbud circuit board **1122** of FIG. **11**A and can include, for example, Bluetooth processor **1812**, circuitry that requires placement close to the processor, balance RF filter circuitry **1814** and coaxial connector (see e.g., connector **2752** of FIG. **27**B). Examples of circuitry required close proximity to processor **1812** can include a timing crystal, charging inductors, capacitors, field effect transistors and resistors.

[0195] Circuit board **1820** corresponds to primary housing circuit board **512** of FIG. **5** and primary housing circuit board **1115** of FIG. **1**A and can, for example, include RF Antenna **1822**, interface circuitry **1823**, power distribution circuitry **1824**, switching circuitry **1825**, 4-pin symmetrical magnetic connector **1826**, RF matching circuitry **1821** and coaxial connector (see e.g., connector **2752** of FIG. **27**B).

[0196] Circuit boards **1810** and **1820** can be electrically coupled using, for example, co-ax cable **1830** and bus **1832**. In the embodiment shown in FIG. **18**, bus **1832** includes ten lines, but one of ordinary skill in the art will appreciate that the number of lines in the bus can vary.

[0197] Balance RF filter circuitry **1814** and RF matching circuitry **1821** can adjust RF signals to compensate for the specific effects of circuit board **1810**, co-ax cable **1830**, circuit board **1820** and antenna **1822**. The functions of elements of additional circuitry in circuit board **1810** and **1820** have been described in more detail in the above discussion relating to FIG. **14**.

[0198] FIGS. **19**A and **19**B compare respective top and bottom views of earbud circuit board **1920** according to an embodiment of the present invention to respective top and bottom views of the known circuit boards shown in FIGS. **17**A-**17**C. In addition, FIGS. **19**A and **19**B show that selected components of known circuit board **1990** can be arranged on earbud circuit board **1920**. For example, as shown, the encircled circuit and components such as components **1996** and processor **1992** can be placed on one or more sides of earbud circuit board **1920**. The remaining electronic components such as components **1996** can be placed on primary housing circuit board (see e.g., circuit board **1115** of FIG. **11**) which may be located inside the headset's primary housing.

[0199] Earbud circuit board **1920** can include a layer made from a flexible substrate that enables circuit board **1920** to bend onto itself, thereby effectively reducing the area needed to install circuit board **1920** into a headset according to the invention. The flexible layer of circuit board **1920** can include one or more layers of electrical traces for electrically coupling processor **1922** and electronic components **1926**, for example. The flexible layer of circuit board **1920** can, for example, extend over the entire footprint of the circuit board, or be limited to predetermined portions of circuit board **1920**.

[0200] Circuit board **1920** can include relatively rigid sections **1923**, **1925** and **1927** which have increased structural strength and are easier to mount electrical components to. Rigid circuit board sections **1923**, **1925**, and **1927** can be fabricated by attaching rigid circuit board pieces to one or more outer surfaces of the flexible layer of circuit board **1920**. Rigid pieces can be attached to a flexible layer using any suitable process, such as applying an adhesive, for example. Contacts can be included on complementary surfaces of the rigid pieces and the flex layer so that electrical traces can be routed across the different layers. One or more layers of electrical traces can be included in the rigid circuit board pieces so that the combination of rigid and flex layers can provide two or more layers of electrical traces. In the embodiment shown in FIGS. **19**A and **19**B, a flex circuit layer with two levels of traces can be located in between two rigid, single-trace layers such that the resulting rigid sections of circuit board **1920** include four layers of traces. In flexible sections of circuit board **1920**, such as connector lead **1921**, the absence of rigid pieces can result in two levels of traces.

[0201] Rigid sections **1925** and **1927** can have substantially circular footprints with different radii. Various electrical components, such as capacitors and resistors, for example, can be mounted on both sides of rigid section **1925**. Rigid section **1927** can have a larger footprint than section **1925** in order to accommodate the mounting of processor **1922** on a first side and receiver **1924** on a second side of section **1925**. Connector **1928** can be mounted to rigid section **1923** to enable earbud circuit board **1920** to electrically couple with a primary housing circuit board (see e.g., circuit board **1115** of FIG. **11**).

[0202] FIGS. **20**A and **20**B show side and perspective views of earbud circuit board **2020** in a folded configuration in accordance with an embodiment of the present invention. Earbud circuit board **2020** may, for example, correspond to earbud circuit board **1920**. The folded configuration may correspond to the configuration of circuit board **2020** when installed within a headset, or more particularly, the earbud of the headset, as shown in FIG. **20**C. Top rigid section **2027** can be folded over middle rigid section **2025** so that both sections can fit in the earbud of a headset. Processor **2022**, receiver **2024** and various other electronic components **2026** may be mounted to earbud circuit board **2020**. Electronic components **2026** can include resistors, capacitors, transistors, amplifiers and other types of both passive and active electronic components, for example. It is to be understood that the term electronic components, as used herein, does not include interconnect devices (e.g., wires, traces, connectors, etc.). Earbud circuit board **2020** can further include rigid section **2023** and connector **2028** mounted thereon. Connector **2028** can be used to electrically couple earbud circuit board **2020** with a circuit board in a headset's primary housing (see e.g., circuit board **1115** or circuit board **2011**).

[0203] Referring now to FIG. **20**C, which shows earbud circuit board **2020** and primary housing circuit board **2011** installed in a possible configuration within headset **2000** in accordance with an embodiment of the present invention. Circuit board **2020** can be folded in a configuration similar to that of FIGS. **20**A and **20**B and inserted into earbud **2014**. Primary housing circuit board **2011** can include a combination of rigid and flexible sections that are similar, in composition but not necessarily shape, to the rigid and flexible sections of circuit board **2020**. Circuit board **2011** can be folded to provide a cavity **2012** for a battery (see e.g., battery pack **1119** of FIG. **11**). Circuit board **2011** can include connector **2018** which may connect to connector **2028** of earbud circuit board **2020**. During installation, circuit board **2011** can be inserted through one of the open ends of primary housing **2010**. Connector lead **2021** can be fed through headset neck **2013** so connector **2028** can mate with connector **2018** when circuit board **2011** has been inserted into primary housing **2010**.

[0204] This distribution of electronics, where processor **2022** and other circuitry (e.g., receiver **2024** and other electronic components **2026**) are located inside earbud **2014**, advantageously allows for a generally smaller and more comfortable headset. Although the discussion above is related to

an embodiment in which a certain distribution of electronic components is used, other distributions can be used without deviating from the spirit of the present invention. For example, a battery can be placed inside the earbud and a processor can be placed in the primary housing.

[0205] FIG. **21**A shows a perspective view of earbud housing **2100** and neck **2110** in accordance with an embodiment of the present invention. Bezel **2130** can cover the top of earbud housing **2100**. One or more acoustic ports **2102** can be located in the wall of the earbud to allow pressure to vent out of earbud housing **2100**.

[0206] FIG. **21**B shows an exploded view of earbud housing **2100** of FIG. **21**A in accordance with an embodiment of the present invention. Screens **2131** and **2132** can be located on top of bezel **2130**. Screens **2131** and **2132** can, for example, provide dust protection and acoustic resistance. Top gasket **2134** can be attached to the underside of bezel **2130** to create a seal with receiver **2124**, and bottom gasket **2123** can be attached to section **2127** (a rigid section) of circuit board **2120**. Bracket **2135** can be used to mount circuit board **2120** inside earbud housing **2100**. Mesh can cover acoustic ports **2102** and can, for example, impose acoustic resistance on air passing through those ports. Screw **2112** can be used to mount earbud housing **2100** to neck **2110**. Gaskets **2134** and **2123** can be made of, for example, foam, rubber, or any other compressible material so that the gaskets can form acoustic (e.g., substantially air-tight) seals with surrounding parts.

[0207] FIG. **22** shows an interior view of empty earbud housing **2200** in accordance with an embodiment of the present invention. Mesh **2204** can be located on the inner wall of housing **2200** to control the flow of air through one or more acoustic ports **2202** and prevent foreign objects (e.g., dirt) from entering housing **2200**. Mesh **2204** can, for example, be affixed to housing **2200** using an adhesive. Mesh **2204** can be made of nylon, plastic, or any other suitable material. Mesh **2204** can provide acoustic resistance to the passage of air between an acoustic volume inside housing **2200** and the outside environment when the earbud is assembled. Even though only one acoustic port is shown in FIG. **22**, any number of acoustic ports can be used in accordance with the principles of the present invention.

[0208] FIG. **23** shows rigid section **2327** of an earbud circuit board mounted inside earbud housing **2300** in accordance with an embodiment of the present invention. Acoustic port **2328** can be provided in circuit board section **2327** to permit air flow through the circuit board. The size, shape and location of acoustic port **2328** can vary depending on, for example, the acoustic properties of the earbud and the desired sound output. If desired, more than one acoustic port may be provided. Although not shown in FIG. **23**, a second rigid portion of the earbud circuit board, such as rigid section **2025** of FIG. **20**, may too include one or more acoustic ports. Though such port(s) may not be necessary if sufficient air gaps exist between the inside wall of housing **2300** and the second rigid portion.

[0209] FIG. **24** shows bottom gasket **2440** mounted onto circuit board section **2427** in accordance with an embodiment of the present invention. Bottom gasket **2440** can include an combination of, for example, acoustic mesh **2430**, adhesive, and foam **2441**. Foam **2441** of gasket **2440** can be shaped to fit around receiver (see e.g., gasket **2740** and receiver **2724** of FIG. **27**A) and acoustic port **2428**. Mesh **2430** can be shaped to cover port **2428**. In this manner, acoustic mesh **2430** can cover acoustic port **2428** even though foam **2441** does not. Mesh **2430** can be made of nylon, plastic, or any other suitable material that can provide acoustic resistance to the passage of air through port **2428** which couples the acoustic volume under circuit board section **2427** (see e.g., acoustic volume **2796** of FIG. **27**) with the acoustic volume where the receiver is located (see e.g., acoustic volume **2794** of FIG. **27**).

[0210] FIG. **25** shows the underside of bezel **2530** in accordance with an embodiment of the present invention. Bezel **2530** can include rim **2536** which extends from the bottom of bezel **2530**. Rim **2536** can be of sufficient height to compress bottom gasket **2440** of FIG. **24** against circuit board section **2427** of FIG. **24** when bezel **2530** is mounted to the top of the earbud housing, thereby creating an acoustic seal between the rim and the circuit board. Gasket **2534** can be, for example, a layer of foam that is affixed to the underside of bezel **2530** using adhesive. Gasket **2534** can be shaped so that it can form a seal with the top of the earbud's receiver when bezel **2530** is mounted to the earbud. Bezel **2530** includes acoustic port **2533** for sound to exit an earbud. Screen **2531** can be located on the topside of bezel **2530** so that the screen completely covers acoustic port **2533**. Screen **2531** can apply an acoustic resistance to air passing through acoustic port **2533**.

[0211] FIG. **26**A shows the underside of bezel **2630** with receiver **2620** installed in accordance with an embodiment of the present invention. Receiver **2620** can be placed inside rim **2636** so that the front output of receiver **2620** is encircled by the seal formed between the top of the earbud's receiver and the top gasket (see e.g., top gasket **2134** of FIG. **21**B). Receiver **2620** can include spring contacts **2622** and **2624**. Spring contacts **2622** and **2624** can, for example, be made from a metal or an alloy. Springs contact **2622** and **2624** can electrically couple with circuitry in a headset in order to input audio signals to receiver **2620**.

[0212] FIG. **26**B shows a cross-sectional view of receiver **2620** in accordance with an embodiment of the invention. Receiver **2620** can include spring contacts **2622** and **2624** which can connect receiver **2620** with a source of electrical signals (e.g., earbud circuit board **1115** of FIG. **11**). Contacts **2622** and **2624** can include tips **2623** and **2625** to facilitate the physical contact with a contact on a circuit (e.g. a flex circuit board).

[0213] FIG. **27**A shows a cross-sectional view of earbud housing **2700** with receiver **2724** and circuit board **2720** installed in accordance with an embodiment of the present invention. Bezel **2730** is mounted on top of earbud housing **2700**. Bezel **2730** can be attached to housing **2700** using a notch and rib configuration **2738** or any other suitable method of attachment, such as adhesive, for example. In an alternative embodiment of the present invention, bezel **2730** can be integrally formed with earbud housing **2700**. Neck **2710** can be coupled to the bottom of earbud housing **2700**. Earbud circuit board **2720** can be located inside the earbud and extend through lumen **2716** of neck **2710**.

[0214] Located on the top of bezel **2730**, screens **2731** and **2732** can cover audio port **2733**. Audio port **2733** can allow air to pass between the external environment **2798** and front volume **2792** of receiver **2724**. Top gasket **2734** and bottom gasket **2740** can create acoustic seals around receiver **2724** so that receiver volume **2794** is created. Acoustic port **2728** can allow air to pass through top rigid section **2727** of circuit board **2720** so that a port between receiver volume **2794** and rear earbud volume **2796** is created. Acoustic port **2702** can be located in earbud housing **2700** so that air can pass between rear earbud volume **2796** and the external environment **2798**.

Mesh (see e.g., mesh **2204** of FIG. **22**) can be applied to the inner wall of earbud housing **2700** to cover acoustic port **2702** such that some resistance is applied to air passing through the port.

[0215] In one embodiment of the present invention, receiver **2724** can form at least part of a wall defining front volume **2792** and at least part of a wall defining receiver volume **2794**. Rim **2736** of bezel **2730** can extend from the bezel into the interior of the earbud and compress against bottom gasket **2740**, thereby also forming at least part of a wall defining receiver volume **2794**. In one embodiment of the present invention, top rigid section **2727** of circuit board **2720** can be disposed between receiver volume **2794** and rear earbud volume **2796**, thereby forming at least part of a wall defining receiver volume **2794** and at least part of a wall defining rear earbud volume **2796**. To ensure the desired acoustic seal between receiver volume **2794** and rear earbud volume **2796**, top rigid section **2727** of circuit board **2720** can be rigidly coupled to earbud housing **2700**, directly or indirectly. In contrast, in one embodiment of the present invention, middle rigid section **2725** of circuit board **2720**, which can be disposed within rear earbud volume **2796**, can be flexibly coupled to the earbud housing, directly or indirectly (e.g., via top rigid section **2727** and flexible section **2729** of circuit board **2720**). As used herein, when a component forms part of a wall defining an acoustic volume, the component can do so directly or indirectly. For example, the component can directly form part of a wall defining an acoustic volume when part of the component is open to the acoustic volume. The component can indirectly form part of a wall defining an acoustic volume when the component is incorporated into another component open to the acoustic volume.

[0216] In order to prevent sound from exiting rear earbud volume **2796** through lumen **2716**, a substance, such as silicon glue, can be used to fill the inside of neck **2710**. It is advantageous to prevent sound from receiver **2724** leaking into the headset's primary housing (see e.g., primary housing **11** of FIG. **1**) because the microphone is located therein. If sound from the receiver is picked up by the microphone, a potentially undesirable echo may be created.

[0217] FIG. **27**B shows a cross-sectional view of earbud housing **2700** with coaxial cable **2750** and conductive stopper **2760** installed in accordance with an embodiment of the present invention. Coaxial cable **2750** can couple to rigid section **2725** of circuit board **2720** using connector **2752**, for example. Coaxial cable **2750** can be used to couple a processor in earbud housing **2700** with an antenna provided in a headset's primary housing (see e.g., antenna **1218** in primary housing **1210**). Coaxial cable **2750** can include, for example, an insulated wire surrounded by a conductive shield and an outer insulator. In some embodiments, the outer insulator may be removed from at least a portion of cable **2750**. For example, insulator can be removed to create exposed portion **2754** of the cable such that the insulator can be electrically coupled with (e.g., grounded to) insert **2712**. Insert **2712** can be grounded to neck **2710** through the insert's threads and the neck can be grounded to a headset's primary housing (see e.g., housing **11** of FIG. **1**). By grounding the insulator of cable **2750**, electromagnetic interference and other negative effects may be reduced thereby increasing the wireless performance of a headset.

[0218] Conductive stopper **2760** can be installed in the lumen **2716** of insert **2712**. In some embodiments, conductive stopper **2760** can be made of silicone and filled with silver. Conductive stopper **2760** can include a slit for circuit board **2720** and coaxial cable **2750** to pass through lumen **2716**. Providing conductive stopper **2760** in neck **2710** can have several benefits. For example, conductive stopper **2760** can help isolate any sounds in acoustic volume **2796** from a headset's primary housing. In some embodiments, conductive stopper **2760** can also press exposed portion **2754** of cable **2750** against the wall of insert **2712** such that the cable's insulator is always electrically coupled with (e.g., grounded to) the insert. In other embodiments, stopper **2760** can be made from a conductive material such that the stopper can electrically coupled exposed portion **2754** of the cable with insert **2712**.

[0219] FIG. **28** shows a view of unassembled pieces of attachment system **2800** that can be used to attach earbud housing **2820** to primary housing **2810** in accordance with an embodiment of the present invention. The configuration described below can allow for a mechanically robust connection which prevents housing **2820** from rotating with respect to primary housing **2810**. An additional benefit of this design is the open lumen that can be used to run wires (or flexible printed circuit boards) between the earbud and primary housing. Attachment system **2800** can, for example, correspond to device **600** of FIGS. **6**A and **6**B.

[0220] Attachment system **2800** can include insert **2840**, earbud housing **2820**, neck **2830**, insert **2850** and primary housing **2810**. In order to simplify manufacturing, inserts **2840** and **2850** can be substantially similar and can both include features **2841**, (e.g., notches), threads **2842** and a through-hole. Features **2841** can be arranged in a pattern to promote proper interface with certain tools. A custom tool which can interface with inserts **2840** and **2850** is described in more detail in the discussion below corresponding to FIGS. **30**A-**30**C.

[0221] Primary housing **2810** can include through-hole **2814**. Insert **2850** can be located in primary housing **2810** so that the threaded part of insert **2850** protrudes through through-hole **2814**. A through-hole can be provided through neck **2830**, and the interior can be threaded so the neck can couple with inserts **2850** and **2840**. Earbud housing **2820** can include an through-hole (see e.g., through-hole **612** of FIG. **6**) through which insert **2840** can pass to couple with neck **2830**.

[0222] The top surface of neck **2830** can include one or more protrusions **2831** (e.g., tabs) which can interface with one or more slots (e.g., notches) in the bottom of housing **2820** to prevent the two parts from rotating independently of each other when coupled together. The slots in the bottom of housing **2820** are not shown in FIG. **28**, but slots similar to slots **2816** can be provided on the neck engaging surface of earbud housing **2820** in accordance with an embodiment of the present invention. Earbud housing **2820** can have a curved exterior surface that can form a nearly seamless transition with the curved exterior surface of neck **2830**.

[0223] The bottom surface of neck **2830** can include protrusions that interface with one or more slots **2816** in housing **2810** to prevent the two parts from rotating independently of each other when coupled together. The protrusions on the bottom surface of neck **2830** are not shown in FIG. **28**, but protrusions similar to protrusions **2831** can be provided on the bottom surface of neck **2830** in accordance with an embodiment of the present invention. Primary housing **2810** can include recessed region **2818** so that the bottom surface of neck **2830** can be recessed below the primary exterior surface of the housing. Moreover, the exterior of neck **2830** can be

shaped to provide a nearly seamless transition from earbud housing **2820** to primary housing **2810**.

[0224] Neck **2830** and inserts **2840** and **2850** can be made from any suitable material (e.g., metals or polycarbonates). For example, neck **2830** can be made from aluminum and inserts **2840** and **2850** can be made from steel. The choice of materials for neck **2830** and inserts **2840** and **2850** can depend on factors such as structural strength, weight, price, ability to be machined, and cosmetic appearance.

[0225] FIG. **29** shows a flowchart of process **2900** for connecting a headset earbud with a primary housing (e.g., a tube) in accordance with an embodiment of the present invention. Note that the protrusions and slots of FIG. **28** are referred to, respectively, as tabs and notches in process **2900**. At step **2901**, a bottom insert (such as insert **2850** of FIG. **28**) can be inserted into a primary housing. The bottom insert can be inserted from either side of the primary housing and manipulated so that the threaded end is protruding from a through-hole in the wall of the primary housing. At step **2902**, thread-locking glue can be applied to the threads of the bottom insert. The glue can be applied so that it covers a complete circular path around the threads of the insert. Alternatively, the glue can be applied to just one section of the threads. The glue can be selected in order to prevent the insert from unscrewing itself due to external forces (e.g., vibration). In one embodiment, a sufficient quantity of glue may be applied to the threads of the insert to prevent moisture and other harmful elements from entering the inside of a headset through a seam which may exist between the neck and the primary housing. At step **2903**, a neck (such as neck **2830** of FIG. **28**) can be screwed onto the insert to a predetermined level. At step **2904**, the neck can be aligned to the primary housing so that one or more tabs (e.g., protrusions **2831**) on the neck fit within one or more notches on the primary housing. At step **2905**, a custom tool can be used to turn the bottom insert while the neck is rotationally fixed to the primary housing. At step **2906**, the bottom insert can be tightened to a predetermined torque. This torque measurement can be estimated by hand or performed with a calibrated torque wrench. At step **2907**, an earbud housing can be mounted to the neck so that one or more tabs on the neck fit within one or more notches on the earbud housing. At step **2908**, thread-locking glue can be applied to the top insert threads. The glue used on the threads of the top insert can be the same as the glue used on the threads of the bottom insert and can be applied in a similar manner. At step **2909**, the top insert can be screwed into the neck. At step **2910**, the top insert can be tightened to a predetermined torque.

[0226] FIGS. **30**A and **30**B show custom tool **3000** that can be used to manipulate an insert (e.g., insert **2840** or insert **2850**) with respect to a neck (e.g., neck **2830**) in accordance with an embodiment of the present invention. Tool **3000** can include two members **3010** and **3020** which can be coupled together by fastener **3030**. Fastener **3030** can allow members **3010** and **3020** to rotate (or pivot) independently around the faster.

[0227] Members **3010** and **3020** can include appendages **3011** and **3021** which can be used by a user to control tool **3000**. Appendages **3011** and **3021** can be an ergonomic size and shape. For example, appendages **3021** can be curved to accommodate an average human hand. Appendages **3011** and **3021** can include plastic covers **3012** and **3022** with ridges **3013** and **3023** such that a user can easily grip the appendages with his/her hands. A spring **3040** can be coupled with appendages **3011** and **3021** such that the appendages are biased to separate from each other.

[0228] Members **3010** and **3020** may control the movement of manipulators **3014** and **3024**, which can interface with a part, such as an insert. For example, when appendages **3011** and **3021** are squeezed together, manipulators **3014** and **3024** may be forced apart. Manipulators **3014** and **3024** can include narrow sections **3015** and **3025** and tips **3016** and **3026**.

[0229] FIG. **30**B shows a detailed view of the shape of tips **3016** and **3026** in accordance with an embodiment of the present invention. Tips **3016** and **3026** can include outward facing tabs **3017** and **3027** which can interface with features (see e.g., features **2841** of FIG. **28**) of inserts in order to manipulate (e.g., screw into place) the inserts. Tabs **3017** and **3027** can form the outer surface of narrow sections **3015** and **3025**.

[0230] FIG. **30**C shows custom tool **3000** coupling neck **3090** with primary housing **3092** in accordance with step **2905** of FIG. **29** according to an embodiment of the present invention. FIG. **30**C illustrates how the narrow section of the manipulators can be of sufficient length so that tabs **3017** and **3027** can interface with features on the insert (see e.g., features **2841** of FIG. **28**). Note that to preserve the structural strength of the manipulators, the narrow section may not be constructed to be substantially longer than necessary.

[0231] Extruded tubes with internal features for securing elements are useful for electronic devices. For example, such tubes can be used as a primary housing (see e.g., housing **11** of FIG. **1**) or an earbud housing (see e.g., earbud **12** of FIG. **1**). The following discussion describes different processes for creating a tube having an internal wall, for example, for supporting circuitry or electronic components. It will be understood, however that the processes and devices described can be used to create any suitable feature on the inner surface of a tubular structure.

[0232] FIG. **31** is a cross-sectional view of a tube having an internal wall **3104** in accordance with an embodiment of the present invention. Tube **3100** has a wall thickness **3102**, and includes internal wall **3104** that extends inward perpendicular from the elongated axis of the tube. Internal wall **3104** has a thickness **3106** and a height **3108** (as measured from the outer surface of the tube). The discussion accompanying FIGS. **32-33**, **34-36**, **37-28**, **39-40**, and **41-43** respectively relate to various methods for creating tube **3100** in accordance with some embodiments of the present invention.

[0233] Known extrusion processes are unable to extrude tubes with internal features such as an internal wall (e.g., internal wall **3104**). For example, known extrusion processes involve forcing a molten material through an aperture in order to create an object with a cross-sectional shape that is similar to the shape of the aperture. This type of process is incapable of producing tubes with discreet internal features because such a tube will have a cross-sectional shape that varies along the length of the tube. To overcome this limitation, existing processes require manufacturing a tube having a wall thickness equal to the required height of the feature (e.g., height **3108**), and subsequently removing excess material around the feature using a machining process so that the final wall thickness meets the desired specification (e.g., thickness **3102**). FIG. **32** is a cross section of an illustrative tube manufactured with a wall thickness that is thicker than the desired end product wall thickness in accordance with an embodiment of the present invention. Tube **3200** may be formed from any material (e.g., metal, plastic, or composite) using any suitable

process (e.g., extrusion, impact extrusion, or progressive deep draw). Wall thickness **3202** may be selected based on the features that will be carved into tube **3200**.

[0234] FIG. **33** is a perspective view of a cross section of the illustrative tube of FIG. **32** once the tube has been machined to include an internal wall in accordance with an embodiment of the present invention. To form internal wall **3204** in tube **3200**, the entire inner surface **3201** of tube **3200** is machined to remove excess material around the internal wall and to reduce tube thickness **3202** to a desired wall thickness. This machining step may be time consuming, expensive, and difficult to implement, as it requires an experienced machinist and expensive tools. Furthermore, machining may also leave marks on the part, which may be undesired (e.g., for aesthetic reasons). Also, some features may include geometry or aspects that cannot be manufactured by machining (e.g., sharp angles not directly accessible from either end of the tube) or features that cannot be manufactured within the required tolerances (e.g., due to the inherent size of the machining tools).

[0235] To overcome the limitations of an entirely machined tube, a number of approaches may be used. FIG. **34** is an illustrative die and stamper for modifying the internal aspect of a tube in accordance with an embodiment of the present invention. Tube **3400** is extruded with the desired final thickness **3402** required for the tube. Tube **3400** is extruded to a slightly longer length **3403** than required for the final product, as the longer portion may be part of a cold-worked process that is used to create the internal wall. A die **3410** may be inserted in a first end of tube **3400** and inserted such that die end **3412** is aligned with a desired location of internal wall **3404** (see FIG. **36**). Die **3410** may fit flush against the inside wall of tube **3400** and may be operative to maintain wall thickness **3402** when stamper **3420** is used to cold-work the tubing not in contact with die **3410**. Stamper **3420** is then inserted into the second end of tube **3400**, and a stamping force is applied to cold work the portion of tube **3400** located between the second end and die **3410**. Stamper **3420** causes the wall thickness **3422** of tube **3400** to increase in the cold worked portion of tube **3400** by forcing the excess tube length to be cold-worked into the internal wall. The shape of stamper **3420** and the distance between the second end of tube **3400** and die end **3412** may be set to obtain the desired thickness for internal wall **3404**.

[0236] FIG. **35** is an cross-sectional view of the tube of FIG. **34** after stamper **3420** and die **3410** are removed from tube **3400** in accordance with an embodiment of the present invention. After stamping, tube **3400** includes two thicknesses, thickness **3402** which is the expected final thickness of the tube, and thickness **3422**, which corresponds a maximum possible height of any internal wall that may be machined from the thicker portion.

[0237] To create internal wall **3404**, portions of inner surface **3401** of tube **3400** may be machined. FIG. **36** is a perspective view of the tube of FIG. **35** when the tube is machined to create an internal wall in accordance with an embodiment of the present invention. The portions of inner surface **3401** having thickness **3422** may be machined to thickness **3402** such that internal wall **3404** remains in tube **3400**. Surface **3430** of FIG. **36** can identify the surfaces that are machined to complete tube **3400**. An advantage of this process over the process described in FIGS. **32** and **33** is that the amount of machining required for the tube can be greatly reduced, as are costs.

[0238] Another approach for forming features in a tube may include impact extrusion of one end of the tube. FIG. **37** is a cross section of an illustrative tube formed using impact extrusion in accordance with an embodiment of the present invention. Tube **3700** having wall thickness **3702** is formed using impact extrusion. Impact extrusion creates an indentation that extends to surface **3710**, which corresponds to the surface of internal wall **3704** (FIG. **38**) of tube **3700**. The end of tube **3700** remains closed by material **3722**.

[0239] To complete tube **3700** and construct internal wall **3704**, material **3722** may be machined. FIG. **38** is a perspective view of the tube of FIG. **37** when tube **3700** is machined to create an internal wall in accordance with an embodiment of the present invention. Material **3722** may be machined to leave inner surface **3701** of tube **3700** with thickness **3702**, and with internal wall **3704** extending from inner surface **3701**. Surface **3730** may represent the surface that is machined to create wall **3704**. Similar to the process of FIGS. **34-36**, this process is advantageous over the process described in FIGS. **32-33** because the amount of machining required for the tube can be greatly reduced.

[0240] Another approach for forming features in a tube may include impact extrusion of both ends of a tube. FIG. **39** is a cross section of an illustrative tube **3900** formed using impact extrusion in accordance with an embodiment of the present invention. Tube **3900** having final wall thickness **3902** is formed using multiple impact extrusions. The impact extrusions create a first indentation **3910** that extends to surface **3912** with surrounding interior surface **3901** and a second indentation **3914** that extends to surface **3916** with surrounding interior surface **3921**. The thickness of tube **3900** left by first indentation **3910** is thickness **3902**, which may be the expected final thickness of the tube. The thickness of tube **3900** left by second indentation **3914** is thickness **3922**. The difference between thickness **3902** and thickness **3922** may correspond to height **3908** of internal wall **3904**.

[0241] In some embodiments, if internal wall **3904** is configured to be constrained between surfaces **3912** and **3916**, the distance between surfaces **3912** and **3916** may correspond to the thickness **3906** of internal wall **3904**.

In embodiments where internal wall **3904** is constrained between surfaces **3912** and **3916**, thickness **3922** may be the same as thickness **3902** (i.e., substantially the expected final thickness of tube **3900**) because internal wall **3904** having height **3908** (as shown in FIG. **40**) may be machined from the material left between surfaces **3912** and **3916**. In such embodiments, height **3908** of internal wall **3904** may be determined by the machining process.

[0242] To complete tube **3900** and construct internal wall **3904**, material between surface **3912** and **3916** may be machined. Material may also be machined from interior surface **3921**. FIG. **40** is a perspective view of the tube of FIG. **39** once the tube is machined to create an internal wall in accordance with an embodiment of the present invention. In some embodiments, material may be machined to leave interior surface **3921** with thickness **3902**, and with internal wall **3904** extending from interior surfaces **3901** and/or **3921**. Surface **3930** of FIG. **40** identifies the surface that may be machined to complete tube **3900**. Similar to the processes of FIGS. **34-36** and **37-38**, this process is advantageous over the process described in FIGS. **32-33** because the amount of machining required for the tube can be greatly reduced.

[0243] Yet another approach for forming features in a tube may include a progressive deep draw process. FIG. **41** is a

cross section of an illustrative tube formed using a progressive deep draw process in accordance with an embodiment of the present invention. Tube **4100** is constructed to have two consecutive indentations **4110** and **4114** having distinct wall thicknesses. Indentation **4110** has wall thickness **4102**, which may be the expected final thickness of tube **4100**, and indentation **4114** has wall thickness **4122**. Tube **4100** may transition from indentation **4110** to indentation **4114** at plane **4112**, which may correspond to the location of internal wall **4104** (FIG. **43**) configured to be constructed in inner surface **4101** (FIG. **43**) of tube **4100**.

[0244] FIG. **42** is a perspective view of a cross section of the tube of FIG. **41** in accordance with an embodiment of the present invention. As shown in FIG. **42**, tube **4100** is closed at the end of indentation **4114** by material **4124**. To complete tube **4100** and construct internal wall **4104**, material **4124** may be machined to open tube **4100**, and indentation **4114** may be machined to reduce thickness **4122** to the thickness **4102** (e.g., the final expected thickness) while leaving internal wall **4104**.

[0245] FIG. **43** is a perspective view of the tube of FIGS. **41** and **42** after the tube is machined to create an internal wall in accordance with an embodiment of the present invention. Surface **4130** of FIG. **43** identifies the surfaces that are machined to complete tube **4100**. Similarly to the process of FIGS. **34-36**, this process is advantageous over the process described in FIGS. **32-33** because the amount of machining required for the tube can be greatly reduced.

[0246] The following flow charts illustrate methods for forming a tube with a feature on the internal surface of the tube using embodiments of the invention described above. Internal features may include, for example, a wall, a protrusion, an aperture, a snap, a shelf, or any other suitable feature. FIG. **44** is a flow chart of an illustrative process for forming an extruded tube with a feature on the internal surface of the tube using a die and stamper in accordance with an embodiment of the present invention. Process **4400** begins at step **4410**. At step **4410**, a tube is extruded and cut to a length that is slightly longer than the desired finished length. At step **4420**, a die is inserted in one end of the tube, such that the end of the die placed in the tube extends to a desired location where the feature is intended to exist in the tube.

[0247] At step **4430**, a stamper is inserted in the second end of the tube. At step **4440**, a force is applied to the stamper to force excess material into the tube, thus cold working the tube to increase the thickness of the tube in the region adjacent the stamper. At step **4450**, the tube is machined to form the feature. Process **4400** then ends at step **4450**.

[0248] FIG. **45** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a single impact extrusion in accordance with an embodiment of the present invention. Process **4500** begins at step **4510**. At step **4510**, an indentation is formed in the material of the tube by impact extrusion such that the end of the indentation aligns with a desired location of the feature in the tube. At step **4520**, the closed end of the material is machined to form the tube and the feature. Process **4500** then ends a step **4520**.

[0249] FIG. **46** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a impact extrusion on both ends of the tube in accordance with an embodiment of the present invention. Process **4600** begins at step **4610**. At step **4610**, a first indentation is formed in the material of the tube using a first impact extrusion. At step **4620**, a second indentation opposing the first indentation is formed in the material using a second impact extrusion. The ends of the first and second indentations may be configured to align with the boundaries of the feature. At step **4630**, the feature is machined in the material remaining between the first and second indentations. Process **4600** then ends at step **4630**.

[0250] In an alternative embodiment of the present invention, steps **4610** and **4620** can be combined into one step, as indicated by the dotted line around steps **4610** and **4620** in FIG. **46**. That is, the first and second indentations can be formed using a single impact. Advantageously, this can be more efficient than forming first and second indentations from two impacts.

[0251] FIG. **47** is a flow chart of an illustrative process for forming a tube with a feature on the internal surface of the tube using a progressive deep draw process in accordance with an embodiment of the present invention. Process **4700** begins at step **4710**. At step **4710**, first and second indentations are formed consecutively using a progressive deep draw process. The interface between the first and second indentations may be configured such that the feature is located at the interface. At step **4720**, the material closing the tube (i.e., not removed by the progressive deep draw process) is removed. At step **4730**, the feature is machined in the inner surface of the tube. Process **4700** then ends at step **4730**.

[0252] It is understood that any of the processes described above in connection with providing a wall in the inner surfaces of a tube may be used to form any other suitable feature on the inner surface of a tube. In addition, it is understood that these processes may be used for non-extruded and non-tubular components. It is also understood that any of the processes described above can be applied to a component formed from injection molded plastic or any other material.

[0253] In order to convey information, such as device status, visual indicator systems can be included in a headset. One type of indicator system can emit different colors of light to indicate what a device is doing. For example, a system in a headset can emit a green light if it is in a telephone conversation and a blinking red light if the battery power is low.

[0254] FIG. **48** shows a simplified cross-sectional view of a visual indicator system **4800** for a headset in accordance with an embodiment of the present invention. Visual indicator system **4800** can, for example, correspond to display system **18** of FIG. **1**, system **700** of FIG. **7**, or display **1013** of FIG. **10**. One or more light sources **4821** and **4822** can be integrated into system **4800**. Light sources **4821** and **4822** can be, for example, LEDs that each emit a different color of light. Each color or combination of colors can be used to signify different information (e.g., the mode of a headset or a function the headset is performing). Light sources **4821** and **4822** can be mounted onto circuit board **4820**. Through circuit board **4820**, the light sources can be electrically coupled with driver circuitry (see e.g., LED driver **1424** of FIG. **14**) that is operable to activate each source individually or in combination. A detailed description of circuitry with this functionality can be found in U.S. Patent Application No. 60/878,852 entitled "Systems and Methods for Compact Multi-State Switch Networks," which is incorporated herein.

[0255] It is understood that, while the embodiment shown in FIG. **48** uses two separate light sources (e.g., light sources **4821** and **4822**), any number of light sources can be provided without deviating from the spirit and scope of the present invention. In some embodiments, a single light source device

can be provided that includes two LEDs such that the device can emit light from either of the LEDs or a combination of the two LEDs. For example, a light source device can be provided that includes a green LED and a red LED. Such a light source device may, for example, emit green light when activating only the green LED, red light when activating only the red LED, and amber light when activating both LEDs in combination.

[0256] Microperforations **4812** can be provided in housing **4810** so that light sources **4821** and **4822** are visible to a user. Outer apertures **4814** of microperforations can have a small diameter so that they are imperceptible to a user when light sources **4821** and **4822** are off. The diameter of inner apertures **4816** can be of a larger size so that they can guide more light through the microperforations. A detailed description of microperforations and their fabrication can be found in U.S. patent application Ser Nos. 11/456,833 and 11/551,988 which are both entitled "Invisible, Light-Transmissive Display System," and which are both incorporated herein. For the purposes of illustration, only five microperforations are shown in FIG. **48**, however a much larger number of microperforations can be used without deviating from the spirit of the present invention. It is further understood that none of the elements of FIG. **48**, including microperforations **2402**, are drawn to scale. **257** While the incorporated U.S. patent application Ser. Nos. 11/456,833 and 11/551,988, both entitled "Invisible, Light-Transmissive Display System," describe microperforations for use with display systems, microperforations can also be used as acoustic ports in accordance with the present invention. For example, one or more microperforations can be provided such that acoustic pressure can pass through the microperforations and exit a volume. For example, acoustic ports **1021** and **1022** of FIGS. **10**A and **10**B may be composed of a plurality of microperforations in earbud **1020**.

[0257] Light diffuser **4830** can be located between circuit board **4820** and an inner wall of housing **4810**. Light diffuser **4830** can, for example, be made of a polycarbonate with sections of varying opacity. Outer core **4832** of diffuser **4830** can be made from a substantially opaque material such that light from light sources **4821** cannot pass through the core. Outer core **4832** can be substantially opaque in that it can transmit 0% to 20% of light. For example, if outer core **4832** is substantially opaque it can deflect light back into inner core **4834** such that the light doesn't exit the sides of the diffuser.

[0258] Inner core **4834** can be located within the inner wall of outer core **4832**. The inner core **4834** of diffuser **4830** can be made from, for example, a combination of substantially transparent or translucent substrate **4835** and diffusing particles **4836** such that the particles are suspended in the substrate. In some embodiments, substrate **4385** can be substantially transparent in that it can transmit 80% to 100% of light. In other embodiments, substrate **4385** can be translucent such that it transmits any 0% to 100% of light. Both substrate **4835** and particles **4836** can be, for example, made from polycarbonate materials of different opacities. Particles **4836** can be made from an opaque or translucent material that alters the path of light through inner core **4834**. Particles **4836** can have any form (e.g., a sphere, a cylinder, a cube, a prism, or an uneven form). In some embodiments, each of particles **4836** can have a different form to simplify manufacturing. The combination of substrate **4835** and particles **4836** can thoroughly diffuse light from the light sources when it exits the top of inner core **4834**. That is, the light from light sources **4821** and **4822** can be evenly spread across the top surface of inner core **4834** so that a user detects an even intensity of light exiting microperforations **4812**.

[0259] It is understood that other diffusion means can be used without deviating from the spirit and scope of the present invention. For example, surface textures, coatings or labels can be applied to a light transmissive material such that any light passing through the material is substantially diffused.

[0260] Inner core **4834** can have a sufficient width **4890** so that it surrounds the footprint of light sources **4821** and **4822**. In one embodiment, inner core width **4890** can be approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters), and the width **4892** of outer core **4832** can be approximately 2.8 millimeters (e.g., between 2.6 millimeters and 3.0 millimeters). In some embodiments, the width of the end of the diffuser proximal to circuit board **4820** can be different from the width of the end of the diffuser proximal to housing **4810**. For example, diffuser **4830** can be in shape similar to a cone such that the width of the end of the diffuser proximal to housing **4810** is smaller than the width of the diffuser proximal to circuit board **4820**. In other words, diffuser **4830** can, for example, be in the shape of a cone having a flattened top.

[0261] The bottom surface of outer core **4832** can extend below the bottom surface of inner core **4834** so that the outer core can be mounted to circuit board **4820** without the inner core damaging light sources **4821** and **4822**. The outer core **4832** can be attached to circuit board **4820** using, for example, an adhesive or any other suitable material.

[0262] In FIG. **48**, light source **4822** is activated and emitting light **4860**. Because of the effect of light diffuser **4830**, light **4862** can be evenly distributed as it exits the diffuser, thereby making it difficult for a person to discern whether the light is being generated by light source **4821** or light source **4822**.

[0263] FIG. **49** shows the exterior of an embodiment of headset **4910** that includes visual indicator **4913** in accordance with an embodiment of the present invention. Headset **4910** may correspond to headset **10** of FIG. **1**, for example. The embodiment shown in FIG. **49** uses LEDs **4921** and **4922** as light sources and includes a cylindrical light diffuser. Visual indicator **4913** can include microperforations **4912** which allow a user to see light being emitted from LEDs **4921** and **4922**. A light diffuser can be included between the LEDs and microperforations **4912** so that the diffused light seen by a user is equally distributed over the microperforations. The diameter **4990** of the microperforated area can be substantially similar to or smaller than the diameter of the diffuser's inner core. Diameter **4990** can be, for example, approximately 1.7 millimeters (e.g., between 1.5 millimeters and 1.9 millimeters).

[0264] Alternatively, the size and shape of the microperforated area could be different from that of the light diffuser. For example, a microperforated area with a noncircular shape can be placed over a light diffuser so that a noncircular indicator is generated. Similarly, the shape of the light diffuser can be non-cylindrical. Moreover, the light diffuser can be larger than the microperforated area so that it can cover the footprint of any other light sources that might be included.

[0265] Numerous light sources of different colors can be used in conjunction with a light diffuser as described above in order to present a visual indicator to a user. Because of the effect of the material in the light diffuser, light from each different source may appear evenly distributed over an area.

In this manner, the entire indicator can appear to change colors as different light sources are activated.

[0266] FIG. **50**A includes a side view of headset **5000** in accordance with an embodiment of the present invention. Connector **5040** can include primary housing **5010**, connector plate **5041**, contacts **5043**, casing **5044** and microphone port **5050**. Connector plate **5041** can include recessed groove **5042** which runs around the perimeter of connector plate **5041**. Groove **5042** can also be referred to as a recessed step in connector plate **5041**. At the top of connector plate **5041**, a microphone port **5050** can be located in groove **5042**.

[0267] There are many benefits associated with placing microphone port **5050** along the edge of connector plate **5041**. By including the microphone port near the connector plate, the microphone can be embedded in the connector which saves space inside the headset housing. The space that is saved can be used to incorporate other functionality or decrease the overall size of the headset. Moreover, locating the microphone port in the groove around the edge of the connector can hide it from view which increases the overall aesthetic appearance of the headset

[0268] FIG. **40**B shows a detailed view of the microphone port area of a connector in accordance with an embodiment of the present invention. The dimensions of port **5050** can include, for example, a width **5090** of approximately 2.5 millimeters and a height **5092** of approximately 0.3 millimeters. These dimensions are merely illustrative and it is understood that other dimensions may be practiced.

[0269] FIG. **51** shows a view of connector **5140** with the primary housing removed in accordance with an embodiment of the present invention. Connector **5140** can, for example, correspond to connector **16** of FIG. **1**, assembly **320** of FIG. **3**, assembly **420** of FIG. **4**, connector **1040** of FIG. **10**, or connector **1140** of FIG. **11**. Connector **5140** can be mounted up primary housing circuit board **5115**, for example. Connector **5140** can include connector plate **5141**, contacts **5143** and accompanying casing **5144** to prevent the contacts from electrically coupling with the connector plate. Microphone port **5150** can be included in the top of connector plate **5141** to allow sound to reach microphone boot **5120**. Microphone boot **5120** and a microphone contained therein can be located behind connector plate **5141**. The microphone can be contained within microphone boot **5120** to, for example, protect the microphone from damage and control the flow of air into the microphone.

[0270] FIG. **52** shows an exploded view of connector **5140** of FIG. **51** which can include, for example, connector plate **5240**, microphone boot **5220**, microphone **5222**, contacts **5243**, casing **5244**, bracket **5248** and screws **5249** in accordance with an embodiment of the present invention. Microphone **5222** can be a MEMs microphone and can be electrically coupled with circuit board **5215**. Circuit board **5215** is similar to primary housing circuit board **1115** of FIG. **11**. Microphone boot **5220** can mount over microphone **5222**. Microphone boot **5220** can, for example, be made of silicon so that it can seal with surrounding parts when connector **5200** is assembled. Contacts **5243** can be included in casing **5244**. Casing **5244** can be made of a non-conductive material (e.g., polymeric) so that contacts can not be electrically coupled with connector plate **5240**. Casing **5244** can be mounted onto circuit board **5215** and include conductive elements (see e.g., shank **5707** and contact segment **5708** of FIG. **57**B) which can electrically couple contacts **5243** with circuit board **5215**. Bracket **5248** can couple with connector plate **5240** in order to hold connector **5200** together. Upward pressure from bracket **5248** can compress microphone boot in order to create an acoustic (e.g., substantially air-tight) seal for the passage of air into and out of microphone **5222**. Circuit board **5215**, casing **5244** and bracket **5248** can include one or more apertures for mounting to connector plate **5240**. Screws **5249** can be inserted through these apertures and screwed into threaded cavities (see e.g., cavities **6046**) on the back of connector plate **5240**.

[0271] FIG. **53** shows a view of microphone boot **5320** which can include input aperture **5325** in accordance with an embodiment of the present invention. Microphone boot **5320** can, for example, correspond to microphone boot **5220** of FIG. **52**. Air that flows into a headset by going around microphone boot **5320** can cause a noticeable loss in the quality of the audio signals picked up by a microphone in the boot. Therefore, microphone boot **5320** can include sealing surface **5326** to prevent air from leaking through any seams along the edge of the microphone boot. Sealing surface **5326** can be a horizontal surface of boot **5320** that extends to the perimeter of the boot's footprint. Sealing seams in this manner can direct the flow of air into aperture **5325** which can result in higher sound quality being received by the microphone.

[0272] Traditionally, the roof of a microphone boot creates a seal with the surfaces of surrounding parts. This can require a thicker roof which is structurally robust enough to support the pressure required to make an adequate seal. Because boot **5320** uses horizontal sealing surface **5326** (instead of roof **5327**) to seal with surrounding parts, roof **5327** does not need to be very thick. This reduced thickness saves space in a housing and can result in a generally smaller or thinner headset.

[0273] FIG. **54** shows a perspective, cross-sectional view of connector plate **5440** which includes microphone boot **5420** and microphone **5422** in accordance with an embodiment of the present invention. Connector plate **5440**, boot **5420** and microphone **5422** can, respectively, correspond to connector plate **5240**, booth **5220** and microphone **5222** of FIG. **52**, for example. The components shown in FIG. **54** can fit together so that air can pass through microphone port **5450**, into boot aperture **5425** and reach microphone input **5421**. Microphone port **5450** may, for example, be a cut-out in the recessed step of connector plate **5440**. Because of other elements in the connector assembly (e.g., circuit board **5215** and bracket **5248**), microphone **5422** and microphone boot **5420** can be pushed up against connector plate **5440** when installed in a headset. The pressure from this force can cause surface **5426** to form a seal with surface **5445** of connector plate **5440**. This seal can prevent air from passing through seam **5490** in between connector plate **5440** and microphone boot **5420**.

[0274] In some embodiments, porous plug **5428** may be provided in boot aperture **5425**. Plug **5428** may be, for example, made from a porous foam (e.g., sintered polyethylene or super high-density polyethylene). Plug **5428** can help filter out high-frequency noises such as those generated by wind blowing into microphone port **5450**. The acoustical performance of plug **5428** can be a factor of its porosity which can be controlled by manufacturing. For example, plug **5428** can be manufactured by melting particles of polyethylene together. The porosity of the resulting plug can be a function of how long the particles are melted, what temperature is used to melt the particles, and the particles size. In some embodiments, it may be advantageous to only use polyethylene particles of a certain size when forming plug **5428**. For example,

particles with a diameter between 177 microns and 250 microns may be melted to form plug **5428**.

[0275] FIGS. **55**A and **55**B show views of the connector of headset **5500** in accordance with an embodiment of the present invention. Four contacts **5561**, **5562**, **5563** and **5564** can be integrated into the connector. The contacts can be of a substantially flat shape so that they are flush with the face of connector plate **5540**. The contacts can, for example, be of an oval shape. The outer contacts **5561** and **5564** can be configured for coupling to either a power supply line or a ground line. The remaining inner contacts **5562** and **5563** can be configured for receiving and transmitting data.

[0276] Connector plate **5540** can be located within primary housing **5510** and can include recessed groove **5542**. Height **5580** of primary housing **5510** can be approximately 5 millimeters or can be from a range between 4.7 and 5.3 millimeters. Height **5581** of the interior cavity of primary housing **5510** can be approximately 4 millimeters or can be from a range between 3.7 and 4.3 millimeters. Height **5582** of the raised face of connector plate **5540** can be approximately 3.3 millimeters or can be from a range between 3.0 and 3.6 millimeters. Heights **5580**, **5581** and **5582** can be advantageous because they can provide a headset having a small form-factor yet large enough to adequately couple with a complementary connector. Heights **5581** and **5582** can also provide an adequate groove for sound from a user's voice to reach a microphone embedded in connector plate **5540** (see e.g., microphone **17** of FIG. **1**). It is understood that these dimensions are merely illustrative. It is also understood that connector plate **5540** and the aperture in primary housing **5510** are angled with respect to the axis of primary housing **5510**, and heights **5580**, **5581** and **5582** reference the orthogonal heights of the corresponding elements.

[0277] Connector plate **5540** can include four contacts **5561**, **5562**, **5563** and **5564** which can be separated by pitch **5583**, which can be approximately 2 millimeters or from a range between 1.75 and 2.25 millimeters. Pitch can be defined as the distance from the centerline of a contact to the centerline of the nearest contact. Pitch **5583** can be advantageous because it can allow contacts on complementary connectors (see e.g., connector **6200** of FIG. **62**A and **62**B) to be sufficiently spaced apart such that magnetic components can be provided between the contacts.

[0278] Each contact can have a width **5584**, which can be approximately 0.7 millimeters or from a range between 0.5 and 0.9 millimeters. The ring of exposed casing can have a width **5586** of approximately 0.2 millimeters or can be from a range between 0.12 and 0.3 millimeters. All of the rings of exposed casing can have the same width (e.g., width **5586**). Width **5586** can be advantageous because it is large enough to prevent contacts **5561**, **5562**, **5563** and **5564** from shorting with connector plate **5540**, but small enough to not impact the size of connector plate **5540**. The contacts can be arranged on the face of connector plate **5540** so that they are symmetrical about the centerline of headset **5500**. Dimension **5585**, which represents the distance from the centerline of each contact to the centerline of the headset, can be approximately 1 millimeter. The dimensions of contacts **5561**-**5564** can be advantageous because the dimensions can provide a sufficient surface for coupling with a corresponding connector while maintaining a small form-factor headset. For example, if the contacts were much larger, the size of housing **5510** may need to increase.

[0279] FIG. **55**C includes a side view of headset **5500** in accordance with an embodiment of the present invention. The angle between the face of connector plate **5540** and the axis of primary housing **5510** can be represented by angle **5587**, which can be approximately 55 degrees or from a range between 10 and 80 degrees. Angle **5587** can be advantageous because it can provide a suitable angle for mating headset **5500** with a corresponding connector. Angle **5587** may also provide an appropriate angle for reflecting sound from a user's mouth to the microphone of headset **5500** (see e.g., microphone **17** of FIG. **1**). Angle **5587** can also be provided to block outside sounds from the microphone of headset **5500**.

[0280] As measured along the surface of connector plate **5540**, the height **5588** of each contact can be approximately 1.5 millimeters. Height **5588** can be advantageous because it provides a substantial surface area for headset **5500** to couple with corresponding headsets but does not necessarily cause an increase in the size of housing **5510**.

[0281] The connector plate **5540** can be recessed in primary housing **5510** by a depth **5589** of approximately 0.25 to 0.3 millimeters. This depth can be determined by measuring the distance between the face of connector plate **5540** and a plane defined by the end of primary housing **5510** (e.g., a plane including three points on the connector end of primary housing **5510**). Depth **5589** can be advantageous because it can provide a sufficient depth to strengthen the mechanical link between headset **5500** and a corresponding connector, but not be of such a large depth that it becomes difficult to align the headset with such a connector.

[0282] FIG. **55**D includes a top view of headset **5500** in accordance with an embodiment of the present invention. Width **5590** of primary housing **5510** can be approximately 12.3 millimeters or can be from a range between 10 and 14 millimeters. Width **5591** of the interior cavity of primary housing **5510** can be approximately 11.1 millimeters or can be from a range between 7 and 13 millimeters. Width **5592** of the raised face of connector plate **5540** can be approximately 10.3 millimeters or can be from a range between 5 and 11 millimeters. Widths **5590**, **5591**, and **5592** can be advantageous because they can provide a large enough area for headset **5500** to securely couple with a complementary connector, while not being so large so as to prevent headset **5500** from having a small form-factor. The dimensions given above apply to the embodiments shown in **55**A, **55**B, **55**C and **55**D and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0283] FIG. **56** illustrates an assembly of electrical contacts for connector **1040** in accordance with an embodiment of the present invention. Assembly **5601** can include plurality of electrical contacts **5602** disposed in non-conductive (e.g., polymeric) casing **5603**. Casing **5603** can include protruding members such that each protruding member can extend through a cavity in a connector plate. In FIG. **52**, for example, casing **5244** includes four protruding members and connector plate **5240** includes four cavities (or apertures). When casing **5244** is coupled with connector plate **5240**, the casing's protruding members will fill those cavities. Accordingly, each protruding member can be referred to as a protruding cavity member as well. Electrical contacts **5602** can extend through at least a portion of depth **5690**. In an assembled headset, each electrical contact **5602** can have a portion disposed in electrical contact with electrical contact **5604** of circuit board **5605**, which can be flexible or rigid.

[0284] FIGS. **57**A and **57**B illustrate an assembly of electrical contacts in accordance with one embodiment of the present invention. Assembly **5701** can include plurality of electrical contacts **5702** disposed in non-conductive casing **5703**. Each electrical contact **5702** can have first portion **5705** and second portion **5704**, each of which are manufactured independently and assembled together thereafter.

[0285] First portion **5705** can have head **5706** and shank **5707**. Head **5706** can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on head **5706** can have a conductive, durable finish that also is aesthetically appealing, for example, nickel, tin cobalt, or a blackened finish. Shank **5707** can be integrally formed with head **5706** or formed independently and then attached to head **5706** using adhesive material (e.g., glue, solder, weld, surface mount adhesion material, etc.). For example, during manufacturing, first portion **5705** can be formed from a cylindrical block of conductive material, turned to create shank **5707**, and stamped or milled to shape head **5706**, for example, into an oval shape.

[0286] Second portion **5704** can have engagement segment **5709** and contact segment **5708**. Engagement segment **5709** can have a hole configured for accepting shank **5707** of first portion **5705** during assembly of electrical contact **5702** to casing **5703**. Conductive adhesive material can be applied during manufacturing to mechanically and electrically couple first portion **5705** and second portion **5704** of electrical contact **5702**. Contact segment **5708** can have an internal surface for engagement with electrical contact **5604** on circuit board **5605** (see FIG. **56**) when in an assembled headset. The engagement surface of contact segment **5708** also can have a finish (e.g., gold-plating) that has good properties for adhering electrical contact **5702** to circuit board **5605**, storage, and corrosion-resistance.

[0287] In one embodiment of the present invention, the center of the internal contact surface of second portion **5704** can be offset from the center of the external surface of first portion **5705** when considered in a plane substantially defined by the external contact surface of first portion **5705**. This can be useful when design constraints require electrical contacts **5702** to electrically couple electronic components that are not co-linearly aligned, as in one embodiment of the present invention illustrated in FIG. **56**. In one embodiment of the present invention, second portion **5704** can have a hook-shape to position the internal contact surface of second portion **5704** in an offset configuration with respect to shank **5707**. In manufacturing, second portion **5704** can be stamped from sheet metal, machined from a solid block of conductive material, molded, or formed using a different method known in the art or otherwise. In one embodiment of the present invention, second portion **5704** can be stamped from sheet metal in high volume production situations to save valuable time and money.

[0288] FIGS. **58**A-**58**C illustrate an assembly of electrical contacts in accordance with another embodiment of the present invention. Assembly **5801** can include plurality of electrical contacts **5802** disposed in non-conductive casing **5803**. Similar to the embodiment illustrated in FIGS. **57**A-**57**B, each electrical contact **5802** can have first portion **5805** and second portion **5804**, each of which are manufactured independently and assembled together thereafter.

[0289] First portion **5805** can have an exposed surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. In one embodiment of the present invention, the exposed surface on first portion **5805** can have a conductive, durable finish that also is aesthetically appealing.

[0290] Second portion **5804** can have engagement segment **5806**, shank **5807**, and contact segment **5808**. Engagement segment **5806** can be electrically and mechanically coupled to first portion **5805** using, for example, surface mount technology, solder, weld, or another conductive adhesive. Shank **5807** can couple engagement segment **5806** to contact segment **5808**. Contact segment **5808** can have an internal surface for engagement with electrical contact **5604** on circuit board **5605** (see FIG. **56**) when headset assembly **5801** is installed in a headset (e.g., headset **10** of FIG. **1**). The engagement surface of contact segment **5808** also can have a finish that has good properties for soldering, storage, and corrosion-resistance.

[0291] In one embodiment of the present invention, the center of the internal contact surface of contact segment **5808** can be offset from the center of the external surface of first portion **5805** when considered in a plane substantially defined by the external contact surface of first portion **5805**. In one embodiment of the present invention, second portion **5804** also can have a hook-shape to position the internal contact surface of second portion **5804** in an offset configuration with respect to the external contact surface of first portion **5805**.

[0292] FIG. **58**C illustrates how assembly **5801** can be manufactured in accordance with one embodiment of the present invention. Initially, second portions **5804** of one or more electrical contacts **5802** can be stamped from single piece of sheet metal **5809** and folded into, e.g., a hook-shape as described above. This can create fingers **5810** in sheet metal **5809** that mechanically and electrically couple all electrical contacts **5802**. First portions **5805**, which also can be stamped in a separate operation, then can be adhered to engagement segments **5806** of each second portion **5804**. This assembly then can be placed in an injection molding machine to injection-mold casing **5803** around the assembly. Once the injection molding procedure is complete, a blade can sever second portions **5804** of electrical contacts **5802** from the rest of sheet metal **5809**, thereby mechanically and electrically decoupling each electrical contact **5802** from the other electrical contacts. Advantageously, because first portions **5805** and second portions **5804** can be formed from a stamping process, assembly **5801** can be used in high volume production situations by saving valuable time and money.

[0293] FIGS. **59**A and **59**B illustrate electrical contacts in accordance with further embodiments of the present invention. Electrical contacts **5901** and **5905** can be similar to that described above with respect to FIGS. **57**A-**58**C, except that electrical contacts **5901** and **5905** can be formed as one unitary piece.

[0294] Electrical contact **5901** can have external contact portion **5902**, shank **5903**, and internal contact portion **5904**. External contact portion **5902** can have an external surface for engagement with an external electrical contact of, for example, a connector on a charging dock or cable. Shank **5903** can couple external contact portion **5902** to internal contact portion **5904**. Internal contact portion **5904** can have an internal surface for engagement with electrical contact **5604** on circuit board **5605** (see FIG. **56**) when electrical contact **5901** is installed in a headset (e.g., headset **10** of FIG.

1). As in the above-described embodiments, the center of the internal contact surface of internal contact portion **5904** can be offset from the center of external contact portion **5902** when considered in a plane substantially defined by the external contact surface of external contact portion **5902**. Electrical contact **5901** also can have a hook-shape to position the internal contact surface of internal contact portion **5904** in an offset configuration with respect to the center of external contact portion **5902**. In one embodiment of the present invention, electrical contact **5901** can be machined from a single block of conductive material.

[0295] Similar to electrical contact **5901**, electrical contact **5905** also can have external contact portion **5906**, shank **5907**, and internal contact portion **5908**. Rather than being machined from a conductive material, however, electrical contact **5905** can be stamped from sheet metal and folded to form the hook-shape. Again, because the electrical contact can be manufactured using a stamping procedure, it can be used in high volume production situations.

[0296] FIGS. **60**A and **60**B show two views of connector plate **6040** of a headset connector in accordance with an embodiment of the present invention. Recessed step **6042** can run around the edge of connector plate **6040** in order to create a groove when the plate is installed in a primary housing (see e.g., primary housing **1110** of FIG. **11**). Microphone port **6050** can be cut out of step **6042** in order to create an opening for sound to reach cavity **6051** where a microphone or microphone boot (see e.g., microphone boot **5220**) can be located. In FIG. **60**B, surface **6045** of connector plate **6040** can be used to compress the perimeter of a microphone boot so that an airtight seal is made.

[0297] Tabs **6047** and threaded cavities **6046** can be used to mount other elements onto connector plate **6040**. For example, tabs **6047** can mate with a bracket that wraps around the entire connector assembly (see e.g., bracket **5248** of FIG. **52**). This same bracket can include apertures for use in conjunction with threaded cavities **6046** so that inserts (e.g., screws) can fix the bracket against connector plate **6040**. Bracket **5248** of FIG. **52** is an example of a bracket that is suitable for use with connector plate **6040**.

[0298] In accordance with one aspect of the present invention, connector plate **6040** can be made of a material with magnetic properties. By incorporating magnetic properties into connector plate **6040**, magnetic effects can be used to enhance the coupling between connector plate **6040** and a complementary connector (see e.g., FIG. **62**B). Connector plate **6040** can include, for example, a ferromagnetic material such as a steel alloy. In another embodiment, connector plate **6040** can include a permanent rare-earth magnet that produces a magnetic field. Moreover, an embodiment of connector plate **6040** can include an electromagnet which produces a magnetic field as a result of the application of electric current. In the electromagnetic embodiment, the magnetic field can be controlled (e.g., through the application of an electric current) so that it is only present when necessary. In the embodiments where connector plate **6040** includes a permanent magnet or an electromagnet, a complementary connector (see e.g., FIG. **62**B) can include a ferromagnetic material or a complementarily positioned permanent magnet or electromagnet.

[0299] FIG. **61**A shows array **6180** of magnetic components which can be embedded in a connector in accordance with an embodiment of the present invention. Array **6180** can include components **6181**, **6182**, **6183**, **6184** and **6185** which can be made of, for example, a permanent rare-earth magnetic material. An example of a suitable material for magnetic components **6181-6185** is magnetized Neodymium and, more specifically, N50 magnets. The magnetic components **6181-6185** can be shaped so that a substantially flat mating face **6186** is formed along one side. This mating face **6186** can, for example, be at an angle complementary to the angle of a headset's connector plate (see e.g., angle **5587** of FIG. **55**).

[0300] FIG. **61**B shows a view of how connector plate **6140** can be used in combination with array **6180** of magnetic components in accordance with an embodiment of the present invention. If connector plate **6140** is made of a ferromagnetic material and array **6180** includes permanent magnets, the magnetic fields of array **6180** will generate magnetic forces biasing connector plate **6140** and array **6180** together. If array **6180** is embedded within a connector that mates with connector plate **6140**, these magnetic forces can reinforce the connection.

[0301] In order to maximize the magnetic field generated by array **6180**, it can be advantageous to arrange components **6181-6185** (e.g., magnets) so that the polarity of each component is in a particular orientation. For example, the components can be arranged so that the south pole of the outer two magnets are closest to the mating face, and the north pole of the inner three magnets are closest to the mating face. In this configuration, if one were to list the polarities encountered when passing horizontally over the mating face, the list would read south-north-north-north-south. This maximization of the magnetic field is one reason why it might be desirable to use an array of magnets as opposed to one large magnet.

[0302] While the embodiments described above include a ferromagnetic connector plate and an array of permanent magnets embedded in a complementary connector (see e.g., FIG. **62**B), it is contemplated that any other magnetic configurations can be used without deviating from the spirit of the present invention. For example, an electromagnet element can be included in the connector plate and a ferromagnetic material can be located in a complementary connector. A detailed discussion about the use of electromagnetic and magnetic elements in connectors can be found in U.S. patent application Ser. No. 11/235,873 entitled "Electromagnetic Connector for Electronic Device" and U.S. patent application Ser. No. and 11/235,875 entitled "Magnetic Connector for Electronic Device," which are both incorporated herein.

[0303] FIGS. **62**A and **62**B show connector **6200** that is complementary to and capable of mating with connector **1040** of FIG. **10**A in accordance with an embodiment of the present invention. Connector **6200** can, for example, correspond to headset engaging connector **220** of FIG. **2**. Connector **6200** can be integrated into, for example, a charger (see e.g., docking station **6400** of FIG. **64**, device **6600** of FIG. **66**, and docking station **6700** of FIG. **67**) which charges a battery in a headset or other apparatus that facilitates the charging of the headset (such as an apparatus discussed in U.S. patent application Ser. No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein).

[0304] The view of connector **6200** in FIG. **62**A does not include connector housing **6210** so that magnetic array **6280** and contacts **6290**, **6292**, **6294** and **6296** can be seen. Array **6280** can be installed in connector **6200** such that it forms a magnetic array structure, and each magnet of the array can be

separated by a gap of predetermined size. Array **6280** of magnetic components can be embedded in connector housing **6210** so that the surface of components **6282**, **6283** and **6284** can be flush with mating face **6286**. These exposed components can extended all of the way to the surface of a corresponding connector plate so that the strongest magnetic forces are generated. However, a connector can have no exposed magnetic elements without deviating from the spirit of the present invention. For example, it can be desirable to recess magnetic components **6281** and **6285** in order to create a smaller connector.

[0305] Contacts **6290**, **6292**, **6294** and **6296** can be included in connector **6200**. In order to integrate the contacts with the array **6280** of magnetic components, each contact can be placed in the gaps between magnetic components. In this manner, contact **6290** can be located in between magnetic components **6281** and **6282**, contact **6292** can be located between components **6282** and **6283**, etc. This integrated distribution of contacts can allow for a smaller connector. This is another example of a reason why it might be desirable to use multiple magnetic components that are spaced apart as opposed to a single, large magnetic component.

[0306] Each contact can include a spring mechanism, such as coil **6297** of contact **6296**. Coil **6297** can bias contact tip **6296** to extend out of connector housing **6210**. The coils **6291**, **6293**, **6295** and **6297** included in the contacts can be substantially planar or flat. A flat coil can allow for minimal spacing between magnetic components **6281-48815**. This reduced spacing can result in a generally smaller connector. However, other types of coils and contacts can be used in accordance with the principles of the present invention. For example, a cylindrical spring biasing a cylindrical contact, commonly called a "pogo pin," can be used without deviating from the spirit of the present invention.

[0307] Contacts **6290**, **6292**, **6294** and **6296** can be position to electrically couple with, for example, the contacts located on the face of a connector plate of a headset. Connector housing **6210** can include an elevated face **6212** which can, for example, fit into a cavity in a complementary connector. For example, if connector **6200** were to mate with headset **1000** of FIGS. **10**A and **10**B, the elevated face **6212** can fit against recessed connector plate **1041** while the edge of primary housing **1010** can fit against the recessed perimeter **6214** of connector **6200**. In this mating configuration, contacts **6290**, **6292**, **6294** and **6296** can be electrically coupled with contacts **1042** of headset **1000**.

[0308] Connector **6200** can include contacts or wires (not shown) on the rear of housing **6210** so that the connector can be electrically coupled with other circuitry. For example, connector **6200** can be mounted onto a circuit board that includes power supply circuitry (such as circuitry discussed in U.S. patent application Ser. No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein) that can be used to transmit power to a headset through one or more contacts.

[0309] FIGS. **63**A and **63**B show connector **6300** that is complementary to and capable of mating with connector **1040** of FIG. **10**A in accordance with an embodiment of the present invention. Connector **6300** is substantially similar to connector **6200** in FIGS. **62**A and **62**B. For example, magnetic components **6382**, **6383** and **6384** of FIG. **63**A are similar, respectively, to magnetic component **6282**, **6283**, and **6284** of FIG. **62**A.

[0310] Connector **6300** can include four contact tips **6390**, **6392**, **6394** and **6396** that can be biased to extend from housing **6310**. Each contact tip can have a width **6303** of approximately 0.5 millimeters. Width **6303** may be advantageously sized to be large enough to easily connect with connectors on headsets (e.g., connector **16** of FIG. **1**) while not being so large that contact tips **6390**, **6392**, **6394**, and **6396** are stiff and cannot be depressed by a headset coupling with connector **6300**.

[0311] The centerline of each contact tip can be separated from the centerline of an adjacent contact tip by pitch **6302**. Pitch **6302** can be chosen so that the contacts of connector **6300** are capable of electrically coupling with the contacts of a headset connector (e.g., connector **1040** of FIG. **10**A). Accordingly, pitch **6302** can be approximately 1.97 millimeters so that it corresponds to pitch **5583** shown in FIG. **55**A. Moreover, pitch **6302** can be selected from a range between 1.75 and 2.25 millimeters. The size of pitch **6302** may also be advantageous for placing magnetic components (e.g., components **6382**, **6383**, and **6384**) in between the contacts of connector **6300**. The centerline of outer contact tips **6390** and **6396** can be separated by width **6301**, which can be approximately 5.1 millimeters or from a range between 4.7 millimeters and 5.4 millimeters. Width **6301** can be selected such that contact tips **6390** and **6394** can couple with the outer contacts of a headset (see e.g., contacts **5561** and **5564** of FIG. **55**). In some embodiments, the outer contacts of a headset may be configured to receive power, and a connector, similar to connector **6300** but not including contact tips **6392** and **6394**, can be provided to transmit only power to the headset. Such a connector may be easier to manufacture and cheaper than connector **6200**.

[0312] Connector **6300** can have a raised face **6312** that is capable of coupling with a headset connector (e.g., connector **1040** of FIG. **10**A). The housing **6310** of connector **6300** can have a total height **6304**, which can be approximately 5.1 millimeters or from a range between 4.9 millimeters and 5.3 millimeters. The total height **6304** of a connector may be advantageously selected to corresponding with the total height of a headset's primary housing (see e.g., height **5580** of FIG. **55**) such that connector **6300** can receive a headset's primary housing. The raised face **6312** of housing **6310** can have a height **6305**, which can be approximately 3.43 millimeters or from a range between 3.2 and 3.7 millimeters. Height **6305** can be selected such that it is less than the height of an internal cavity inside of a headset's primary housing (see e.g., height **5581**) such that connector **6300** can easily couple with a headset. In summary, heights **6304** and **6305** can be selected in order to complement heights **5580** and **5581** of FIG. **55**B. Thereby allowing headset **5500** to mate with connector **6300**. It is understood that the mating face of connector **6300** is angled with respect to the rest of the connector. This angle can, for example, range from ten to thirty degrees. Heights **6304** and **6305** reference the orthogonal heights of the corresponding elements. This is similar to the radial dimensions that are shown in FIG. **55**B.

[0313] In order to apply pressure to the contacts of a complementary connector, the contact tips **6390**, **6392**, **6394** and **6396** can be biased to extend from connector housing **6310**. When no complementary connector is present, contact tips **6390**, **6392**, **6394** and **6396** can extend from the housing by distance **6306** of approximately 0.7 millimeters. Distance **6306** can be selected such that the contact tips can advanta-

geously apply enough pressure to a headphone's contacts such that the tips can reliably couple with the headphone's contacts.

[0314] Connector **6300** can also include contacts or wires (not shown) that allow the connector to route electrical signals from contact tips **6390**, **6392**, **6394** and **6396** to other circuitry. The dimensions given above apply to the embodiments shown in **63**A and **63**B and it is understood that other dimensions can be used without deviating from the scope of the present invention.

[0315] FIG. **64** shows a view of headset **6498** coupled with connector **6499** in accordance with an embodiment of the present invention. Headset **6498** can be substantially similar to headset **1000** of FIGS. **10**A and **10**B and can include the features shown on connector **1040**. Connector **6499** can be installed in, for example, docking station **6400** which can include a socket in which a headset can be inserted. Docking stations substantially similar to or the same as docking station **6400** are discussed in U.S. patent application Ser. No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices" which is incorporated herein. The socket in docking station **6400** can be shaped to align headset **6498** properly with respect to connector **6499**. Connector **6499** can include raised face **6412** and lower perimeter **6414** to further align headset **6498**. Raised face **6412** can extend into the cavity created by a recessed headset connector while the headset's primary housing abuts perimeter **6414**.

[0316] This alignment can result in the contacts of headset **6498** (see e.g., contacts **1042** of FIG. **10**A) being approximately centered over the tip of contact **6490**. Contact **6490** can be biased to extend beyond raised face **6412** by coil **6491**. This bias can be represented by a force exerted in the direction of arrow **6401**. Additionally, arrow **6402** can represent the magnetic force generated by the proximity of the connector plate of headset **6498** (see e.g., connector plate **1041** of FIG. **10**A) to the array of magnetic components of connector **6499** (see e.g., array **6180** of FIG. **61**). This magnetic force can cause contact **6490** to electrically couple with a contact on headset **6498**. Connector **6499** can include additional contacts (see e.g., contacts **6290**, **6292**, **6294** and **6296**) which can couple with the remaining contacts of headset **6498**. Connector **6499** can be mounted on circuit board **6480** in docking station **6400** such that circuit board **6480** can route signals to and from headset **6498** when it is coupled with connector **6499**.

[0317] FIG. **65** shows graph **6500** which depicts the approximate change of the two forces described above as the separation between the magnetic components and the connector plate varies in accordance with an embodiment of the present invention. In graph **6500**, x-axis **6502** can represent the approximate force, and y-axis **6504** can represent the distance between the magnetic components and the connector plate. The separation where the x-axis intercepts the y-axis is zero, and this point can represent when the connector plate is in contact with the magnetic components. As the separation increases, approximate force **6508** from spring contacts pushing on a connector plate in a headset can decrease linearly because of the substantially linear nature of coil springs. While the spring force decreases linearly, the approximate magnetic force **6506** can decrease exponentially due to the behavior of magnetic materials.

[0318] It can be desirable to choose magnetic components (e.g., magnets, connector plates) and design spring components (e.g., contact coils) such that the magnetic force biasing a headset's connector plate to a complementary connector is greater than the force of the spring contacts pushing back on the connector plate at all possible distances of separation between the two parts. If there are situations where the spring force is greater than the magnetic force, it might be necessary to apply an external force in order to properly couple a headset with a complementary connector. Applying this external force might require intervention from a user, and therefore, it can be desirable to design a connection system so that the magnetic force is always greater that the spring force.

[0319] FIG. **66** shows charging device **6600** that can be used in conjunction with a headset in accordance with an embodiment of the present invention. In some embodiments, connector **6601** can be integrated into device **6600**, thereby allowing device **6600** to be electrically coupled with a headset. Connector **6601** is similar to the connectors discussed in connection with FIGS. **61**-**65**.

[0320] In some embodiments, auxiliary connector **6610** can be integrated into charging device **6600**. As such, auxiliary connector **6610** can be used to couple an additional device, such as a cellular phone which can be used with a headset, to device **6600**. In order to connect a headset or additional device to an external power supply (e.g., wall outlet or computer), device **6600** can include cable **6620**. Circuitry **6630** can be integrated into device **6600** to facilitate charging of both a headset and an additional device. Circuitry **6630** can also provide a communications interface for data to be shared between a headset and an additional device. An example of a charging device similar to device **6600** is discussed in detail within U.S. patent application Ser. No. 11/620,669 entitled "Apparatuses and Methods that Facilitate the Transfer of Power and Information Among Electrical Devices," which is incorporated herein.

[0321] FIGS. **67**A and **67**B show connector **6710** in accordance with an embodiment of the present invention. The face of connector **6710** can be shaped to include peak **6711**. By incorporating peak **6711** into the connector face, connector **6710** is capable of mating with a headset in two different interface orientations (e.g., physical orientations). When connector **6710** is installed in docking station **6700** (see FIG. **67**B), peak **6711** creates cavities **6702** and **6704** which can each accept the long side **6721** of headset **6720**. In the interface orientation shown in FIG. **67**B, side **6721** of headset **6720** is in cavity **6704**. However, if headset **6720** were inserted in another orientation, long side **6721** of the headset may be in cavity **6702**. In either of these orientations, the contacts of connector **6710** can be electrically coupled with the contacts on headset **6720**.

[0322] In some embodiments, switching circuitry can be included in headset **6720** to compensate for these different interface orientations. Such switching circuitry can determine the interface orientation of headset **6720** and connector **6710** and route signals received from the connector to pathways inside the headset (e.g., electrical traces) based on the determined orientation. In other embodiments, switching circuitry can be provided in docking station **6700** that can determine the interface orientation of connector **6710** and headset **6720** and route signals to the connector based on the determined orientation. A detailed discussion of similar switching circuitry can be found in U.S. patent application Ser. No. 11/650,130 entitled "Systems and Methods for Determining the Configuration of Electronic Connections," which is incorporated herein.

[0323] Similar to the elevated face **6212** and recessed perimeter **6214** shown in FIG. **62**B, raised face **6712** and recessed perimeter **6714** can be advantageous when coupling a headset (see e.g., headset **1000** of FIGS. **10**A and **10**B) to connector **6710**. For example, raised face **6712** and recessed perimeter **6714** can provide structural features that strengthen the mechanical coupling of connector **6710** and a headset.

[0324] FIG. **68** shows chart **6800** listing exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. With regards to chart **6800**, a communications system can include a headset (e.g., headset **10** of FIG. **1**) and a host device (e.g., a cellular telephone, a laptop computer, etc.). Further defining the communications system referenced in chart **6800**, the headset can be in communication with the host device and the host device can be communicating with other devices through a cellular network or other communications network (e.g., Voice over Internet Protocol).

[0325] Chart **6800** includes rows describing exemplary modes and functions of the system and columns identifying inputs and outputs that correspond to each mode or function. Some of the functions listed in column **6810** typically occur when a system is in a certain mode, and therefore, these functions can be listed under their respective modes. For example, the answer call function **6812** and the reject call function **6813** are typically executed when a system is in incoming call mode **6811** and chart **6800** can reflect this by listing functions **6812** and **6813** directly under incoming call mode **6811**.

[0326] For each row corresponding to a function, column **6820** can be used to identify an input that can cause that function to occur. For example, column **6820** may identify a manner in which a user can press a single button on a headset (see e.g., button **14** of FIG. **1**) to initiate a corresponding function. It is understood that the initiated function may further depend on the mode in which a headset is in. For example, a long button press may initiate the reject call function **6813** if a system is in incoming call mode **6811**, while the same type of button press may initiate function **6814** if the system is in another mode. Examples of using a single button to control an electronic device can be found in U.S. Provisional Patent Application No. ______ entitled "Single User Input Mechanism for Controlling Electronic Device Operations," which is incorporated herein.

[0327] Outputs can be associated with each mode or function so that, for example, a user can be aware of a system's operation. Such outputs may be provided through a headset display system (see e.g., display system **18** of FIG. **1**), a headset audio system (e.g., speaker system **13** of FIG. **1**), and/or host device user interface (UI). A display screen and a speaker on a host device can, for example, be part of a host device UI used to provide outputs. Column **6830** lists outputs that can be provided by a headset display system to correspond with modes or functions listed in column **6810**. For example, if a headset's display system includes an indicator that can output different colors using LEDs, column **6830** can include different colors and/or flashing patterns that the indicator can output based on the communication systems mode or function. Column **6840** lists outputs that can be provided by a headset audio system (e.g., a speaker) based on the communication system's mode or function. Column **6840** can, for example, include beeps, tones, or other noises that can be used to notify the operation of the communications system. Column **6850** lists outputs that can be provided by a Host Device UI. For example, column **6850**, may include outputs that can be presented through a display screen on a host device.

[0328] In summary, chart **6800** identifies the inputs and outputs corresponding to various exemplary modes and functions of a communications system in accordance with an embodiment of the present invention. For example, when a communications system is in incoming call mode **6811**, the system's headset (e.g., headset **10** of FIG. **1**) can display a slow blinking green light and output two beeps while the system's host device can display an incoming call screen (e.g., a graphic displaying information about the incoming call). Continuing the example, if a user presses a button on the headset (e.g., button **14** of FIG. **1**) for a short amount of time, the system can answer the call while the headset displays a green light and outputs a short low tone followed by a short high tone. While the system is answering the call, the host device can display a call answer screen. It is understood that the modes and functions shown in FIG. **68** and discussed above are merely exemplary and that communication systems can operate using other modes and functions without deviating from the spirit and scope of the present invention.

[0329] Although particular embodiments of the present invention have been described above in detail, it will be understood that this description is merely for purposes of illustration. Alternative embodiments of those described herein are also within the scope of the present invention. For example, while one embodiment can include a Bluetooth headset, one or more features of the present invention also can be incorporated into headsets employing other wired and/or wireless communication protocols. Also, while some embodiments of the present invention can include headsets configured for communication with a cellular phone and/or personal media device (e.g., a portable media player similar to that sold under the trademark ipod® by Apple Inc. of Cupertino, Calif.), one or more features of the present invention can also be incorporated into headsets configured for communication with any electronic device. Furthermore, while one embodiment illustratively described above can include a headset and methods for fabricating the same, one or more features of the present invention can also be incorporated into other electronic devices that require, e.g., circuit boards distributed within small acoustic volumes, symmetric connectors, extruded housings having one or more internal features, microperforations, co-located microphones and connectors, magnetic connectors, or any combination thereof.

[0330] Various configurations described herein may be combined without departing from the present invention. The above described embodiments of the present invention are presented for purposes of illustration and not of limitation. The present invention also can take many forms other than those explicitly described herein. Accordingly, it is emphasized that the invention is not limited to the explicitly disclosed methods, systems and apparatuses, but is intended to include variations to and modifications thereof which are within the spirit of the following claims.

What is claimed is:

1. An electronic device comprising:

a housing;

a connector assembly coupled to the housing, the connector assembly comprising a microphone port;

a microphone mounted within the housing; and

a channel that fluidically couples the microphone to the microphone port.

2. The device of claim **1**, wherein the microphone is mounted within the connector assembly.

3. The device of claim **1**, wherein the connector assembly further comprises:

a connector plate constructed to receive the microphone and include the microphone port.

4. The device of claim **3**, wherein the microphone port is located on the periphery of the connector plate.

5. The device of claim **4**, wherein the microphone port is adjacent to the housing.

6. The device of claim **3**, further comprising:

a microphone boot, wherein the microphone is coupled to the microphone boot.

7. The device of claim **6**, wherein the microphone boot acoustically seals the microphone.

8. The device of claim **6**, wherein the microphone boot comprises:

a sealing portion that forms an acoustic seal with the connector plate; and

a roof portion constructed to form a portion of the channel.

9. The device of claim **6**, wherein the microphone boot is constructed substantially of silicone.

10. The device of claim **1**, further comprising a circuit board electrically coupled to the connector assembly and the microphone.

11. The device of claim **1**, wherein the microphone port is recessed within the housing.

12. The device of claim **1**, wherein a relatively air tight seal exists between the connector assembly and the housing.

13. The device of claim **1**, wherein the connector assembly is operative to electrically couple with another electronic device.

14. A joint connector and microphone assembly comprising:

a microphone including a top surface and side surfaces, the top surface comprising a microphone input;

a microphone boot mounted to the microphone such that the boot interfaces with a portion of the top surface and the side surfaces to form a seal around the microphone input, the microphone boot comprising:

a connector sealing portion; and

an aperture for fluidically coupling the microphone input to a microphone port; and

a connector plate mounted to the connector sealing portion.

15. The assembly of claim **14**, wherein the connector plate comprises:

a recessed step; and

a cut-out provided through a portion of the recessed step, the cut-out forming the microphone port.

16. The assembly of claim **14**, wherein the connector plate comprises at least one aperture.

17. The assembly of claim **16**, further comprising:

at least one contact that fits into the at least one aperture.

18. The assembly of claim **16**, further comprising:

a circuit board;

a casing mounted to the connector plate and electrically coupled to the circuit board;

at least one contact that fits into the at least one aperture; and

a bracket that fixes the at least one contact to the connector plate and enables the connector plate to exert acoustic sealing pressure to at least the boot.

19. The assembly of claim **18**, further comprising at least one screw to secure the bracket to the casing.

20. The assembly of claim **18**, wherein at least a portion of the circuit board is flexible.

21. An electronic device comprising:

an earbud assembly;

a primary housing assembly fixed to the earbud assembly, the primary housing assembly comprising an integrated connector and microphone assembly, the integrated connector and microphone assembly comprising:

a microphone port; and

a microphone operative to receive acoustic signals transmitted through the microphone port.

22. The device of claim of claim **21**, further comprising a neck assembly for mounting the earbud assembly to the primary housing assembly.

23. The device of claim **21**, wherein the device is a headset.

24. The device of claim **21**, wherein the device is a Bluetooth headset.

25. The device of claim **21**, wherein the integrated connector and microphone assembly comprises:

a microphone boot for acoustically sealing the microphone.

26. The device of claim **21**, wherein the integrated connector and microphone assembly comprises:

a cavity extending from the microphone to the microphone port.

27. The device of claim **21**, wherein the primary housing assembly comprises a circuit board coupled to the integrated connector and microphone assembly.

28. The device of claim **21**, wherein the integrated connector and microphone assembly is recessed a predetermined distance within the primary housing assembly.

29. The device of claim **21**, wherein a connector end of the primary housing assembly includes a planar region that is angled to a first predetermined angle with respect to a central axis passing lengthwise through the primary housing assembly.

30. The device of claim **29**, wherein the first predetermined angle is a non-perpendicular angle.

31. The device of claim **30**, wherein the integrated connector and microphone assembly includes an assembly planar region that is angled to a second predetermined angle with respect to the central axis passing lengthwise through the primary housing assembly.

32. The device of claim **31**, wherein the first and second predetermined angles are substantially the same.

* * * * *

US008031900B2

(12) **United States Patent**
Dyer et al.

(10) **Patent No.: US 8,031,900 B2**
(45) **Date of Patent: Oct. 4, 2011**

(54) **EARPHONE AMBIENT EARTIP**

(75) Inventors: **Medford Alan Dyer**, San Diego, CA (US); **Jerry J. Harvey**, Newport Beach, CA (US)

(73) Assignee: **Logitech International, S.A.** (CH)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1434 days.

(21) Appl. No.: **11/363,006**

(22) Filed: **Feb. 27, 2006**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04R 25/00 (2006.01)

(52) **U.S. Cl.** **381/380**; 381/381; 381/322; 381/328; 181/130; 181/135

(58) **Field of Classification Search** 381/312, 381/322–330, 380–381; 181/130, 135
See application file for complete search history.

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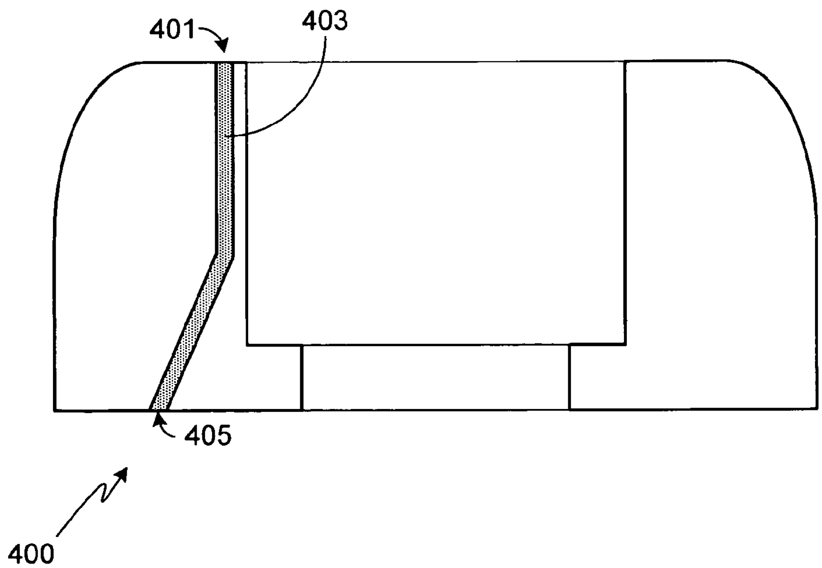
Assistant Examiner — Jasmine Pritchard
(74) *Attorney, Agent, or Firm* — Patent Law Office of David G. Beck

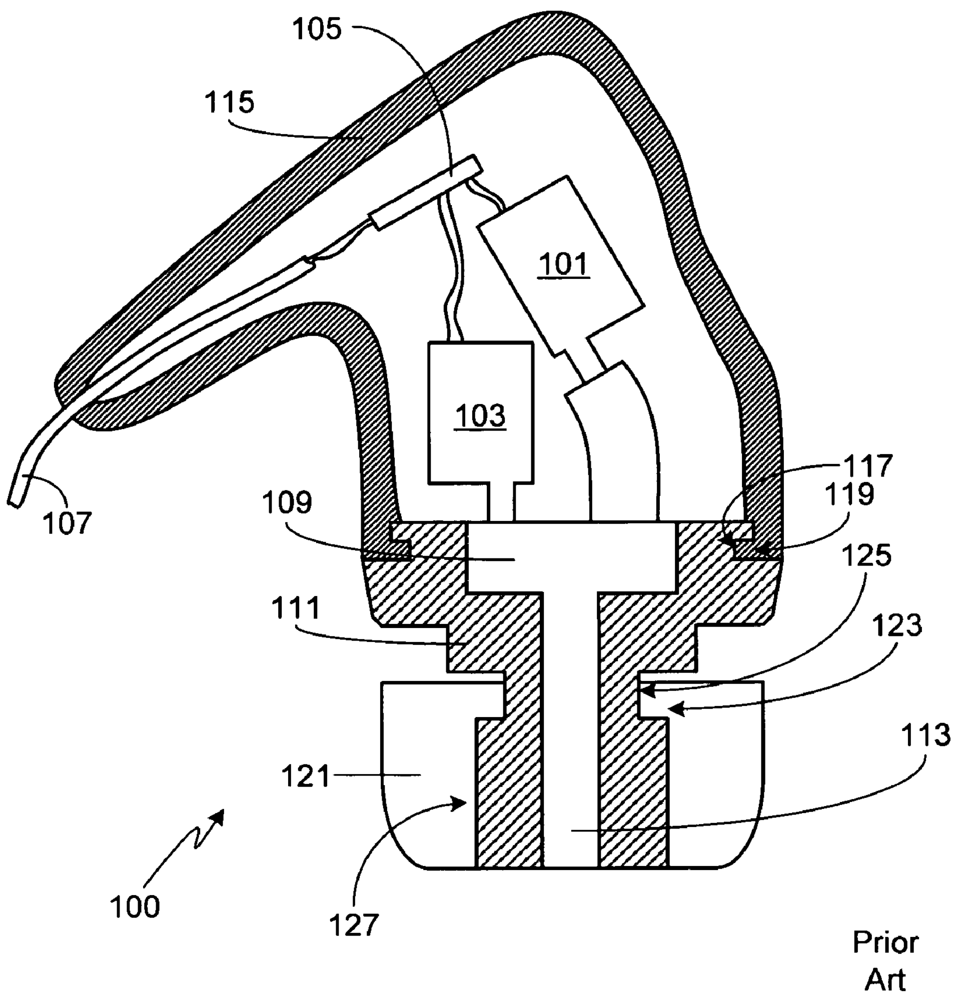
(57) **ABSTRACT**

An eartip that includes at least one acoustic material filled port is provided. The port and the acoustic material contained therein provide the eartip with a controlled acoustic leakage path, thus allowing the user to tailor the performance of the earphones to which the eartips of the invention are attached. The provided eartip is attachable to a standard, generic ear-piece, for example through the use of interlocking members (e.g., channel/lip arrangement). At least one port, in addition to the central opening by which the eartip is attached to the earphone, extends through the eartip. The port can have a circular cross-section, arcuate cross-section, or other shape. If desired, for example to increase the port area, the eartip can be designed with multiple ports surrounding the central opening. Within the port is an acoustic material with the desired acoustic impedance. The eartip can be coded to allow identification of the acoustic qualities of a particular eartip.

19 Claims, 8 Drawing Sheets



APPLE 1006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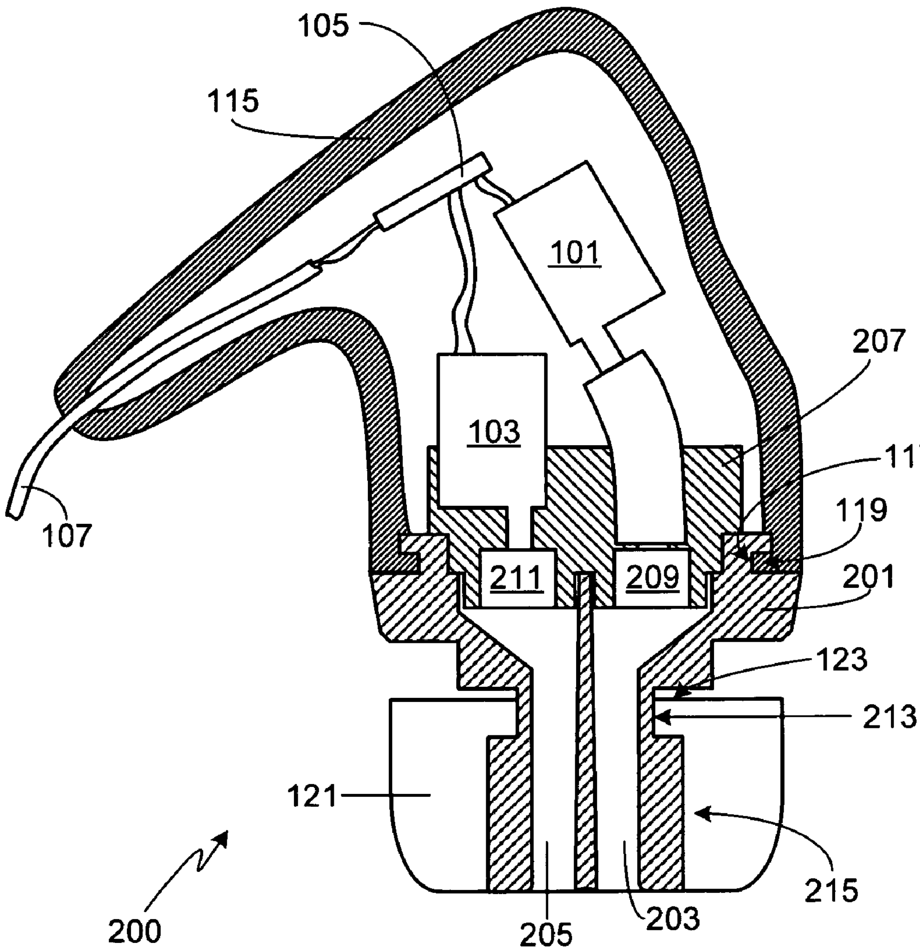
Prior
Art

FIG. 1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Prior
Art

FIG. 2

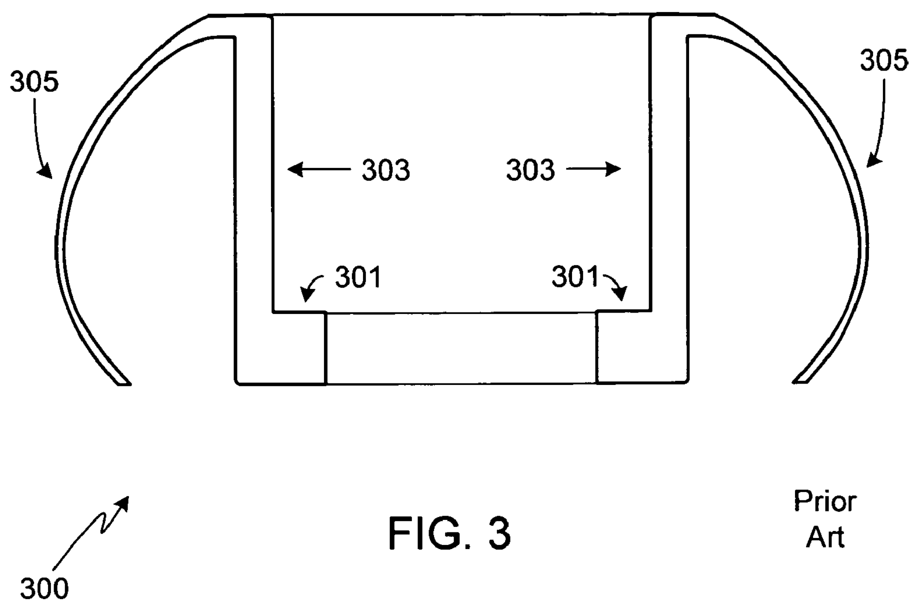

FIG. 3

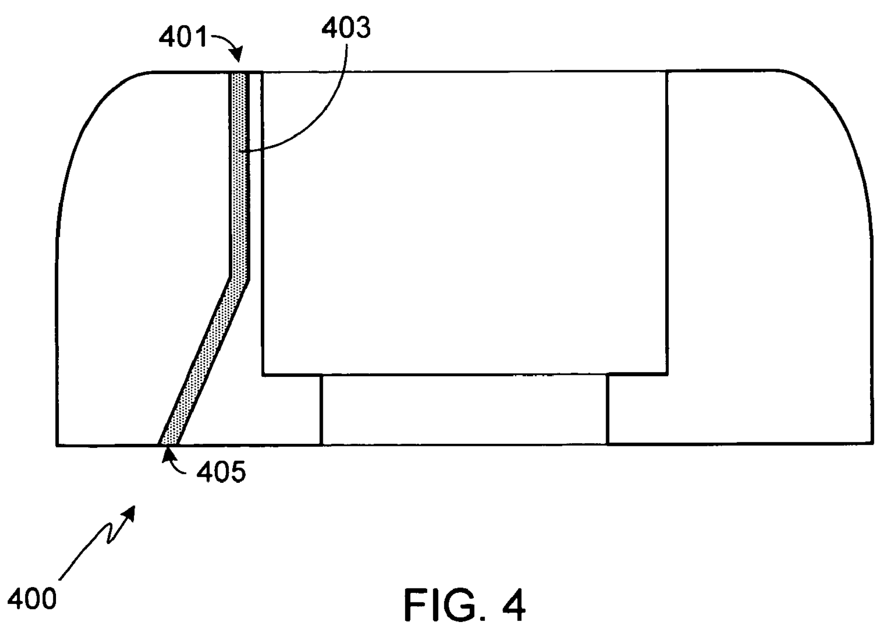

FIG. 4

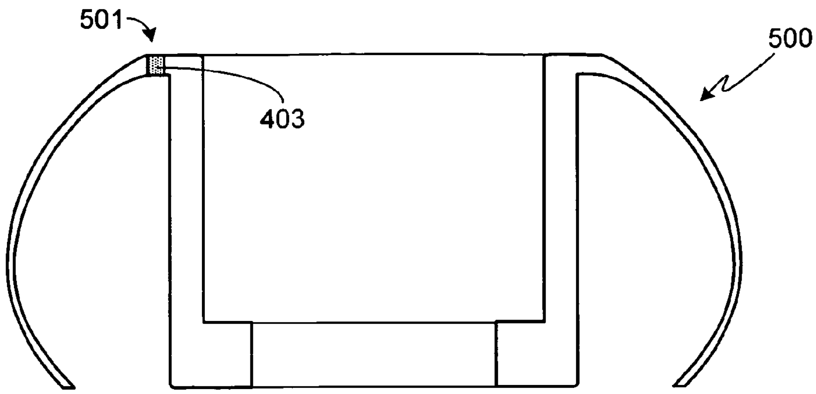

FIG. 5

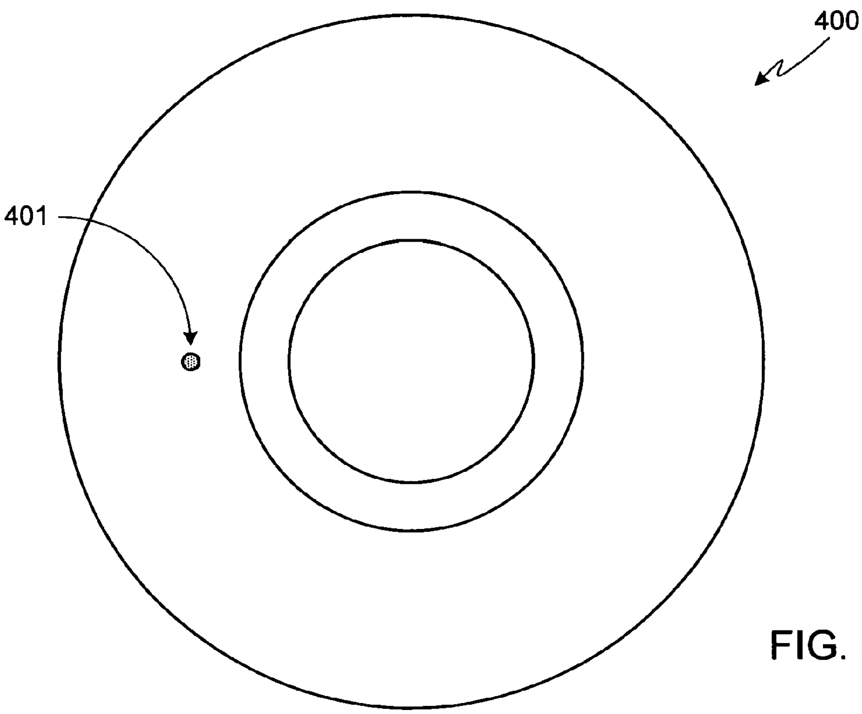

FIG. 6

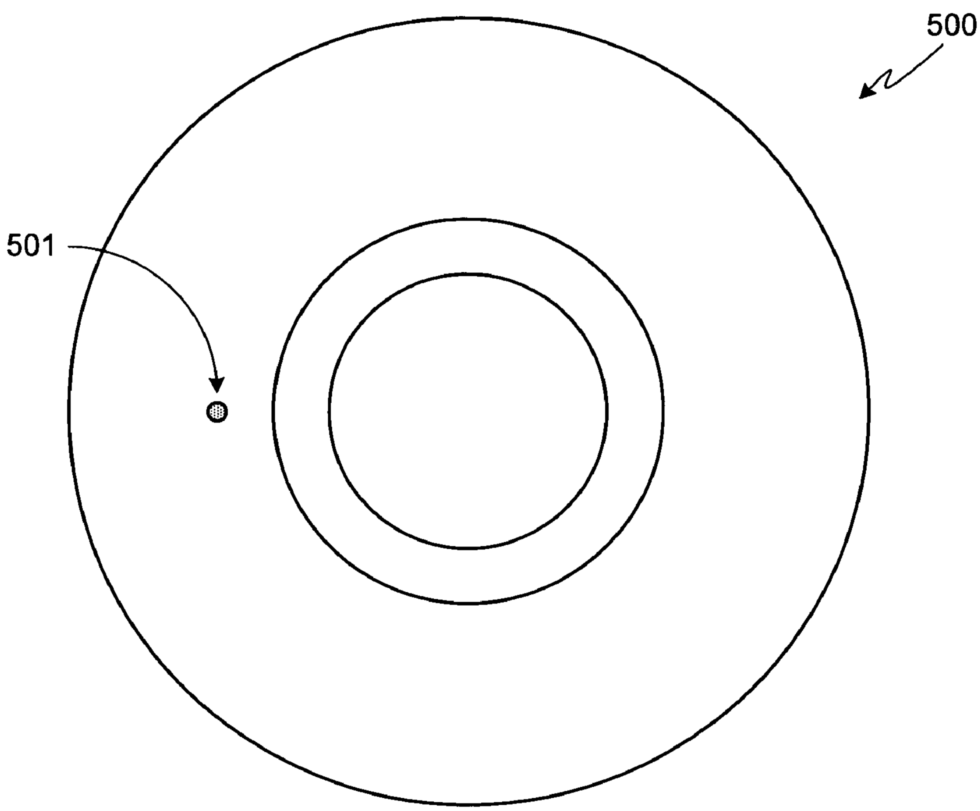

FIG. 7

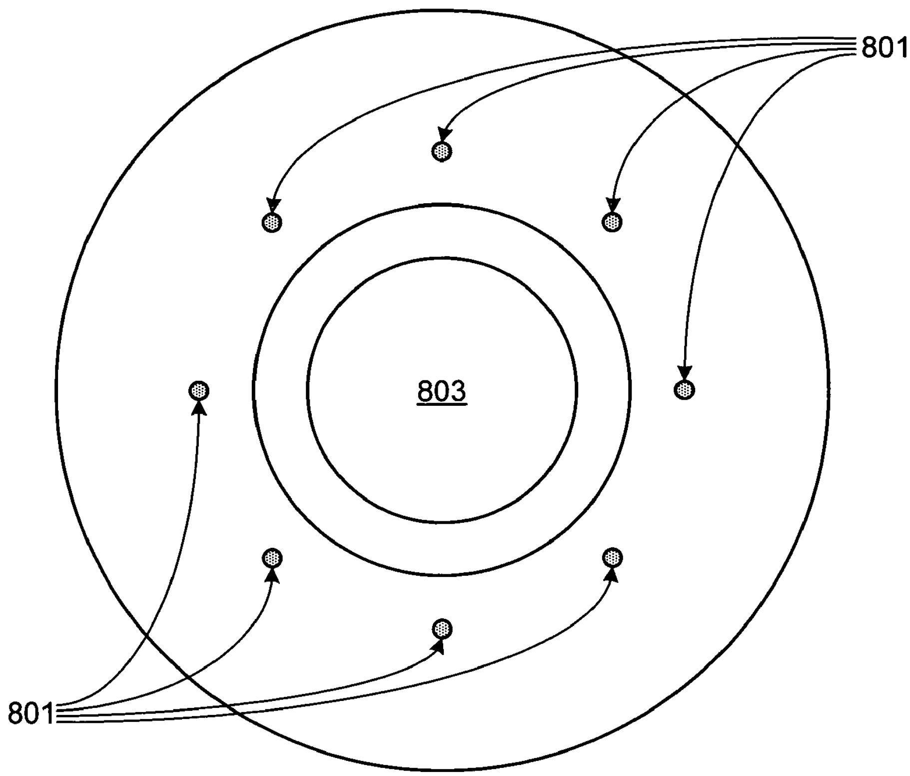

FIG. 8

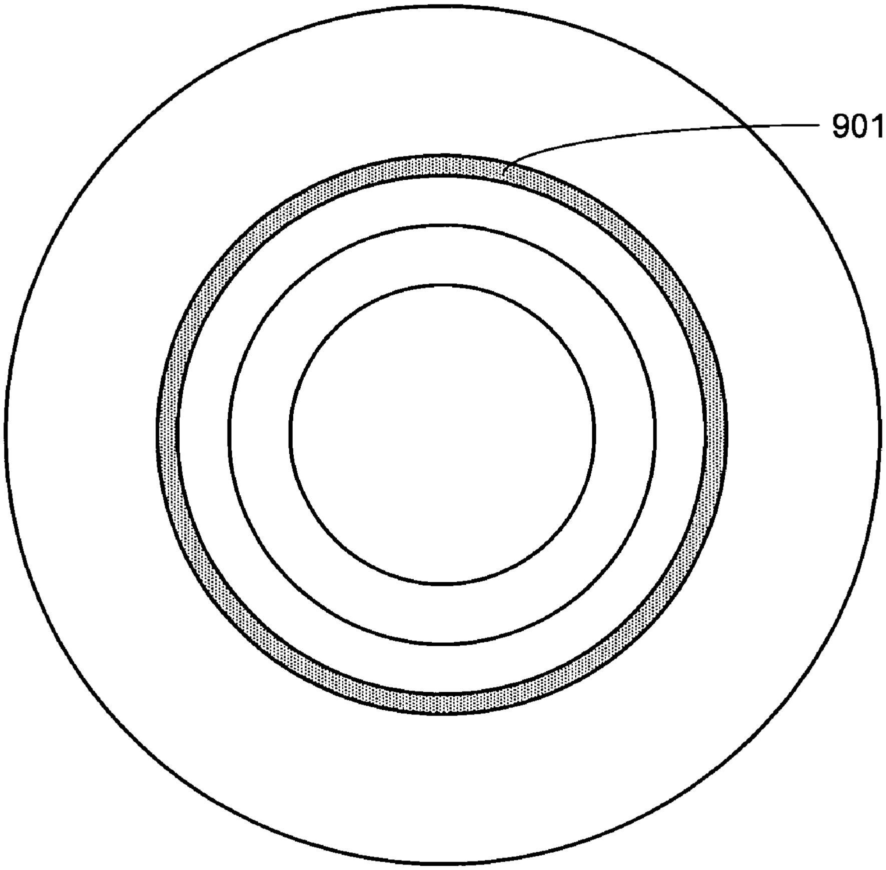

FIG. 9

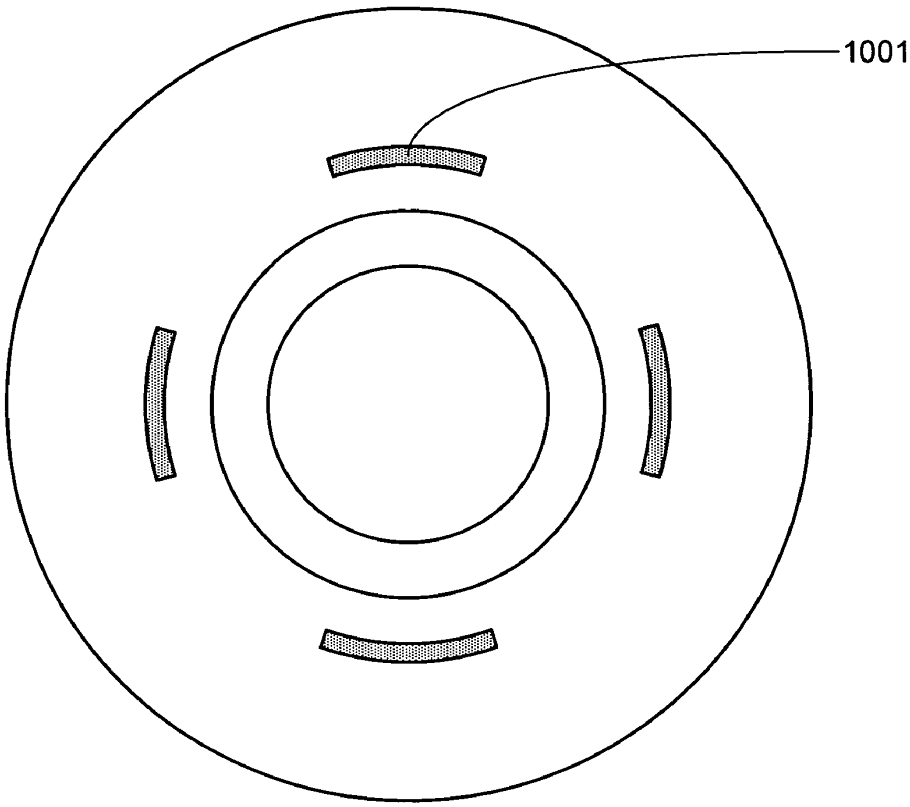

FIG. 10

EARPHONE AMBIENT EARTIP

FIELD OF THE INVENTION

The present invention relates generally to audio monitors and, more particularly, to an earphone eartip.

BACKGROUND OF THE INVENTION

Earphones, also referred to as in-ear monitors, canal phones and earpieces, are commonly used to listen to both recorded and live music. A typical recorded music application would involve plugging the earphone into a music player such as a CD player, flash or hard drive based MP3 player, home stereo, or similar device using the earphone's headphone jack. Alternately, the earphone can be wirelessly coupled to the music player. In a typical live music application, an on-stage musician wears the earphone in order to hear his or her own music during a performance.

Earphones are typically quite small and are worn just outside the ear canal. Prior art earphones use either one or more diaphragm-based drivers, one or more armature-based drivers, or a combination of both driver types. Broadly characterized, a diaphragm is a moving-coil speaker with a paper or mylar diaphragm. Since the cost to manufacture diaphragms is relatively low, they are widely used in many common audio products. In contrast to the diaphragm approach, an armature receiver utilizes a piston design. Due to the inherent cost of armature receivers, however, they are typically only found in hearing aids and high-end in-ear monitors.

Armature drivers, also referred to as balanced armatures, were originally developed by the hearing aid industry. This type of driver uses a magnetically balanced shaft or armature within a small, typically rectangular, enclosure. A single armature is capable of accurately reproducing low-frequency audio or high-frequency audio, but incapable of providing high-fidelity performance across all frequencies. To overcome this limitation, armature-based earphones often use two, or even three, armature drivers. In such multiple armature arrangements, a crossover network is used to divide the frequency spectrum into multiple regions, i.e., low and high or low, medium, and high. Separate armature drivers are then used for each region, individual armature drivers being optimized for each region. In contrast to the multi-driver approach often used with armature drivers, earpieces utilizing diaphragm drivers are typically limited to a single diaphragm due to the size of the diaphragm assembly. Unfortunately, as diaphragm-based monitors have significant frequency roll off above 4 kHz, an earpiece with a single diaphragm cannot achieve the desired upper frequency response while still providing an accurate low frequency response.

In addition to utilizing one or more high-fidelity drivers, professional-quality earphones are either custom molded or they use generic eartips, also referred to as sleeves. Eartips are typically fabricated from a soft, pliable material such as foam or silicon in order to achieve the desired snug fit within the user's ear canal. In use, the eartips isolate the user, thus insuring that the user can hear every nuance of the reproduced audio source by minimizing the audio interference caused by competing background noise.

Although sound isolating earphones meet the requirements of many users, for example professional musicians, some users prefer to be able to hear a degree of background sound. This preference may be for convenience, for example to hear the telephone while using the earphones, or for safety, for example to hear traffic and/or emergency vehicles while cycling. Currently users must select the type of earphone based on the intended use, or at least the primary intended use. As a result, either the user must buy multiple earphone sets to accommodate different uses, or suffer with varying performance inadequacies. The present invention is designed to overcome this problem.

SUMMARY OF THE INVENTION

The present invention provides an eartip that includes at least one acoustic material filled port, the port and the acoustic material contained therein providing the eartip with a path for controlled acoustic leakage. As a result of this controlled acoustic leakage, the user is able to tailor the performance of the earphones to which the eartips of the invention are attached, for example allowing varying levels of ambient sound to intrude upon the sound produced by the earphone, thereby limiting the sound isolation afforded by the eartip. The controlled acoustic leakage of the eartip can also be used to tailor the response of the earphone, for example lessening the earphone's base response.

The eartip of the invention is attachable to a standard, generic earphone, for example through the use of interlocking members (e.g., channel/lip arrangement). At least one port, in addition to the central opening by which the eartip is attached to the earphone, extends through the eartip. The port can have a circular cross-section, arcuate cross-section, or other shape. If desired, for example to increase the port area, the eartip can be designed with multiple ports surrounding the central opening. Within the port is an acoustic material with the desired acoustic impedance. Typical acoustic materials are fabricated from foam or fibrous material, although the invention is not limited to these materials. Preferably the eartip of the invention includes an indicator, such as color coding, that allows the user to easily identify the acoustic qualities of the selected eartip.

In one embodiment of the invention, a kit of eartip pairs of varying acoustic impedance is provided. The user selects the eartip pair based on the desired earphone performance, thus allowing the earphone frequency response and/or the degree of sound isolation to be varied as preferred.

A further understanding of the nature and advantages of the present invention may be realized by reference to the remaining portions of the specification and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of a generic earphone in accordance with the prior art;

FIG. **2** is a cross-sectional view of a generic earphone with multiple sound delivery tubes in accordance with the prior art;

FIG. **3** is a cross-sectional view of an alternate prior art eartip;

FIG. **4** is a cross-sectional view of an eartip similar to that shown in FIGS. **1** and **2**, with the inclusion of a controlled leakage port;

FIG. **5** is a cross-sectional view of an eartip similar to that shown in FIG. **3**, with the inclusion of a controlled leakage port;

FIG. **6** is an end view of the eartip shown in FIG. **4**;

FIG. **7** is an end view of the eartip shown in FIG. **5**;

FIG. **8** is an end view of an eartip with multiple ports surrounding the central eartip opening;

FIG. **9** is an end view of an eartip with a circular port surrounding the entire central eartip opening; and

FIG. **10** is an end view of an eartip with multiple arcuate ports surrounding the central eartip opening.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

FIG. **1** is a cross-sectional view of a generic earphone **100** in accordance with the prior art. Earphone **100**, also referred to herein as an earpiece, in-ear monitor and canalphone, includes a low-frequency driver armature driver **101** and a high-frequency armature driver **103**. A circuit **105**, such as a passive crossover circuit or an active crossover circuit, provides input to armature drivers **101** and **103**. Crossover circuit **105** is coupled to the external sound source (not shown) via a cable **107**. Only a portion of cable **107** is shown. The external sound source may be selected from any of a variety of sources such as an audio receiver, mixer, music player, headphone amplifier or other source type. As is well known in the industry, earphone **100** can also be wirelessly coupled to the desired source. Although dual armature drivers are shown in FIG. **1**, it will be appreciated that the invention is equally applicable to other driver configurations, for example with fewer or greater numbers of drivers as well as those using either diaphragm drivers, armature drivers, or both.

As illustrated, the output from each driver enters an acoustic mixing chamber **109** within sound delivery member **111**. A single sound delivery tube **113** delivers the mixed audio from the two drivers through the sound delivery member **111** to the user. Sound delivery member **111** is designed to fit within the outer ear canal of the user and as such, is generally cylindrical in shape. It will be appreciated that although a single sound delivery tube **113** is shown in the embodiment illustrated in FIG. **1**, the invention is not limited to earphones of this design. For example, assuming the use of multiple drivers, multiple sound delivery tubes can be used as described in co-pending U.S. patent application Ser. Nos. 11/051,865, filed Feb. 4, 2005, and 11/333,151, filed Jan. 17, 2006, the disclosures of which are incorporated herein for any and all purposes. An exemplary embodiment of a multiple sound tube configuration is shown in FIG. **2**. As shown, sound delivery member **201** of earphone **200** includes two separate sound delivery tubes **203**/**205**, corresponding to drivers **101** and **103**, respectively. Preferably a boot member **207**, which can also be used in other configurations such as that shown in FIG. **1**, attaches to sound delivery member **201**, boot member **207** securing the components to the sound delivery member.

Regardless of the configuration, earphones utilizing the present invention can include internal dampers, also commonly referred to as acoustic filters. Although not shown in FIG. **1**, the embodiment illustrated in FIG. **2** includes a pair of dampers **209**/**211** interposed between the drivers **101**/**103** and sound delivery tubes **203**/**205**. In the embodiment illustrated in FIG. **1**, the damper could be located within the mixing chamber **109**, for example. Dampers, interposed between the driver(s) and the sound delivery tube(s) and/or the sound delivery tube(s) and the earphone output, are often used to tune the earphone, for example by reducing the output level for a particular frequency range or reducing the overall sound pressure level.

An outer earphone enclosure **115** attaches to sound delivery member **111** (or member **201** in FIG. **2**). Earphone enclosure **115** protects the drivers (e.g., drivers **101**/**103**) and any required earphone circuitry (e.g., crossover circuit **105**) from damage while providing a convenient means of securing cable **107**, or a cable socket, to the earphone. Enclosure **115** can be attached to member **111** (or member **201**) using interlocking members (e.g., groove **117**, lip **119**). Alternately, an adhesive or other means can be used to attach enclosure **115** to member **111** (or member **201**). Enclosure **115** can be fabricated from any of a variety of materials, thus allowing the

designer and/or user to select the material's firmness (i.e., hard to soft), texture, color, etc. Enclosure **115** can be either custom molded or designed with a generic shape.

Attached to the end portion of sound delivery member **111** (or member **201**) is an eartip **121**, also referred to as an eartip sleeve or simply a sleeve. Eartip **121** can be fabricated from any of a variety of materials including foam, plastic and silicon-based material. Sleeve **121** can have the generally cylindrical and smooth shape shown in FIGS. **1** and **2**, or can include one or more flanges. To hold sleeve **121** onto member **111** (or member **201**) during normal use but still allow the sleeve to be replaced when desired, typically the eartip includes a lip portion **123** which is fit into a corresponding channel or groove **125** in sound delivery member **111** (or groove **213** in sound delivery member **201** of FIG. **2**). The combination of an interlocking groove **125** with a lip **123** provides a convenient means of replacing eartip **121**, allowing sleeves of various sizes, shapes, or colors to be easily attached to the earphone. As a result, it is easy to provide the end user with a comfortable fit at a fraction of the cost of a custom fit (i.e., molded) earphone. Additionally, the use of interlocking members **123** and **125** allow worn out eartips to be quickly and easily replaced. It will be appreciated that other eartip mounting methods can be used with earphone **100**. For example, eartip **121** can be attached to sound delivery member **111** using pressure fittings, bonding, etc.

Although eartip **121**, as illustrated in the cross-sectional views of FIGS. **1** and **2**, is solid, it will be appreciated that other configurations can be used. For example, FIG. **3** is a cross-sectional view of an alternate eartip **300**. As shown, preferably eartip **300** includes a lip portion **301**, thus allowing it to be easily attached to the sound delivery member groove as previously described and illustrated relative to eartip **121**. Portion **303** of eartip **300** is cylindrically-shaped, thus providing a secure fit against the barrel-shaped portion of the sound delivery member (e.g., portion **127** of member **111**, portion **215** of member **201**, etc.). Eartip **300** also includes a pliable portion **305** designed to provide both a tight and comfortable fit within the user's ear canal.

In accordance with the invention, one or more controlled acoustic leakage ports are included within the eartip. It should be appreciated that the controlled leakage ports of the invention are not simply open ports, rather they are ports that include a material selected to provide the desired acoustic impedance. Uncontrolled leakage, i.e., that resulting from an open port, is undesirable as it degrades the sound quality to an unacceptable level. Accordingly the present invention provides controlled leakage, thus achieving the benefits of a ported earphone without the significant drawbacks associated with an open port.

FIGS. **4** and **5** are cross-sectional views of eartips **400** and **500**, similar to eartips **121** and **300**, respectively, except for the inclusion of controlled impedance ports **401** and **501**. As shown, ports **401** and **501** are cylindrically-shaped and filled with the desired acoustic material **403**. FIGS. **6** and **7** provide end views of eartips **400** and **500**, respectively.

The acoustic impedance of an eartip designed in accordance with the invention depends, in part, on the area of the controlled impedance port or ports integrated into the eartip. The primary constraint placed on the available area for integrating one or more ports into the eartip is the surface area of the exit surface of the eartip that opens into the ear canal, as opposed to the side surfaces of the eartip that are immediately adjacent to, and fit against, the inner ear canal. Additionally, the back surface of the port or ports must remain unblocked when the eartip is attached to the earphone. Thus, for example, the back surface **405** of port **401** in eartip **400** is

moved away from the centerline to insure that it is not blocked when attached to sound delivery member **111**.

It should be appreciated that there are countless designs for the port, depending upon the desired port area. For example, FIG. **8** is an illustration of an end view of an eartip with multiple ports **801** surrounding the central eartip opening **803**. In the alternate design shown in FIG. **9**, port **901** is circular, surrounding the entire central eartip opening. In another alternate design shown in FIG. **10**, multiple arcuate ports **1001** surround the central eartip opening.

The acoustic material comprising the eartip acoustic ports of the invention can be fabricated from any of a variety of materials, although typically the material is either made of a foam or a fibrous material (e.g., woven cloth-like material). The acoustic material is selected on the basis of its acoustic impedance such that the selected material provides the desired acoustic transmission. If desired, the selected acoustic material can also be selected on the basis of its acoustic transmission for a specific range of frequencies, for example preferentially transmitting the range of frequencies that include voices and emergency sirens.

In a preferred embodiment of the invention, the user is provided with multiple eartip pairs, assuming a headset with both left and right channels, each eartip pair having a different acoustic impedance. Thus the user is able to tailor the acoustic properties of their headset for a particular use. Furthermore given the easy interchangeability of eartips, the user is able to quickly modify their headset as needed. Preferably each eartip includes an identifier such as a color code or other marking, thus allowing its acoustic properties to be quickly ascertained.

In addition to providing a means of adjusting the sound isolation properties of a set of earphones, the controlled leakage eartips of the present invention can also be used to adjust the frequency response of the earphones. As a result, it is possible for a single set of earphones to be adjusted to match the listening preferences of a variety of users. For example, the base response of a set of earphones can be easily adjusted by varying the leakage of the eartips.

As will be understood by those familiar with the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosures and descriptions herein are intended to be illustrative, but not limiting, of the scope of the invention which is set forth in the following claims.

What is claimed is:

1. An eartip fabricated from a first material and configured for coupling to an earphone, said eartip comprising:

a central opening within said eartip, said central opening configured to accept an earphone sound delivery member;

means for attaching said eartip to said earphone sound delivery member;

at least one port within said eartip, said at least one port forming at least one acoustic leakage pathway independent and separate from said earphone sound delivery member, wherein said at least one port is adjacent to said central opening, and wherein said acoustic leakage pathway couples ambient sound to an exit surface of said eartip; and

acoustic material filling at least a portion of said at least one port, said acoustic material different from the first material used to fabricate the eartip, wherein said acoustic material is selected from the group of materials consisting of foam and fibrous material, and wherein said acoustic material is selected on the basis of its acoustic impedance.

2. The eartip of claim **1**, wherein a first end of said at least one port is within a user ear canal during earphone use, and wherein a second end of said at least one port is positioned to receive ambient sounds during earphone use.

3. The eartip of claim **1**, wherein said central opening is cylindrically shaped.

4. The eartip of claim **1**, wherein said attaching means further comprises a first interlocking member on an exterior surface of said earphone sound delivery member and a second interlocking member on an inner surface of said central opening of said eartip.

5. The eartip of claim **1**, wherein said attaching means further comprises a channel on an exterior surface of said earphone sound delivery member and a lip on an inner surface of said central opening of said eartip, wherein said lip fits within said channel when said eartip is attached to said earphone sound delivery member.

6. The eartip of claim **1**, wherein said at least one port has a circular cross-section.

7. The eartip of claim **1**, wherein said at least one port has an arcuate shaped cross-section.

8. The eartip of claim **1**, wherein said at least one port is comprised of a plurality of ports surrounding said central opening.

9. The eartip of claim **8**, wherein each of said plurality of ports has a circular cross-section.

10. The eartip of claim **8**, wherein each of said plurality of ports has an arcuate shaped cross-section.

11. The eartip of claim **1**, further comprising an indicator associated with an acoustic property of said eartip.

12. An eartip kit for use with a set of earphones, said eartip kit comprising:

a plurality of eartip pairs of varying acoustic impedance, wherein each eartip pair includes a first and a second eartip, and wherein each of said first and second eartips comprises:

a central opening configured to accept an earphone sound delivery member;

at least one port adjacent to said central opening, said at least one port forming at least one acoustic leakage pathway independent and separate from said earphone sound delivery member, and wherein said acoustic leakage pathway couples ambient sound to an eartip exit surface;

acoustic material filling at least a portion of said at least one port, wherein said acoustic material is selected from the group of materials consisting of foam and fibrous material, wherein said acoustic material defines said acoustic impedance of said eartip pair, and wherein said acoustic impedance of each eartip pair is different due to differences in said acoustic material selected for each eartip pair; and

visual coding indicative of said acoustic impedance of said eartip pair.

13. The eartip kit of claim **12**, wherein each eartip of each eartip pair of said plurality of eartip pairs further comprises a first interlocking member on an inner surface of said central opening configured to couple to a second interlocking member on an exterior surface of said earphone sound delivery member.

14. The eartip kit of claim **12**, wherein each eartip of each eartip pair of said plurality of eartip pairs further comprises a lip on an inner surface of said central opening configured to fit within a channel on an exterior surface of said earphone sound delivery member.

15. The eartip kit of claim **12**, wherein said at least one port has a circular cross-section.

16. The eartip kit of claim **12**, wherein said at least one port has an arcuate shaped cross-section.

17. The eartip kit of claim **12**, wherein said at least one port is comprised of a plurality of ports surrounding said central opening.

18. The eartip kit of claim **17**, wherein each of said plurality of ports has a circular cross-section.

19. The eartip kit of claim **17**, wherein each of said plurality of ports has an arcuate shaped cross-section.

* * * * *

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Michael J. Koss		
U.S. Patent No.:	10,491,982	Attorney Docket No.:	50095-0019IP1
Issue Date:	November 26, 2019		
Appl. Serial No.:	16/528,701		
Filing Date:	August 1, 2019		
Title:	SYSTEM WITH WIRELESS EARPHONES		

SUPPLEMENTAL DECLARATION OF DR. JEREMY COOPERSTOCK

wireless communications across short distance or local area networks. Superior education could compensate for a deficiency in work experience, and vice-versa.

11. The Patent Owner has alleged that such a "POSITA would not necessarily have any skills or knowledge specific to designing the acoustic transducer for a wireless earphone, fitting all of the components into a small form factor earphone, or suitably powering a wireless earphone given the safety and size constraints." Resp., 6-7. While someone with a bachelor's degree in EE or CS may focus on technologies less relevant to wireless devices, someone who is more interested in such technologies would gain the knowledge that prepares them for the wireless sector, circuitry design, acoustic factors, and other relevant technologies.

12. Designing the acoustic transducer for a wireless earphone, fitting all of the components into a small form factor earphone, or suitably powering a wireless earphone given the safety and size constraints were known at the Critical Date. This is evidenced by the '982 patent's lack of disclosure regarding these concepts. The '982 patent's lack of details on the accused concepts, indicates that such concepts were well-known or easy to obtain by a person with knowledge on wireless headphones at the Critical Date.

13. The Patent Owner's allegation that a POSITA would not have a

reasonable expectation of success because I, with "skills and experience superior to a POSITA, could not explain **important aspects** of the relied-upon prior art," is also flawed. Resp., 12-15 (emphasis added). The Patent Owner's allegation is wrong because I understand the concepts that are needed to implement the prior art combination earphones discussed in my Declaration. Further, the Patent Owner's allegedly "important aspects" were merely conventional concepts that a POSITA would have understood how to implement with a reasonable expectation of success and without any undue experimentation. An engineer interested in seeking to implement Rosener and Hankey earphones would have available many reference to describe the embodiments disclosed in those references, for example, by going through user manuals of well-known transceivers, studying about and experimenting with the alternative techniques that Rosener disclosed, and (if needed) learning about details of flexible circuit board that were available in the market.

A. A POSITA would have had a reasonable expectation of success in selecting and using proper transducers for Rosener-Hankey earphones.

14. Rosener generally described a few example alternative transducers that were commercially known at the time that Rosener was filed. A POSITA reading Rosener's disclosure would have understood such features to be

conventional, and would have no issue in using them in implementing Rosener's contemplated design. The POSITA could simply seek references that explain details of the operations of any of those transducers as those transducers were commercially available by the Critical Date. Indeed, a POSITA had access to information on properties, characteristics and use of those transducer types as well as many other transducer types by the Critical Date.

15. The '982 patent itself also does not mention selecting a transducer as an issue, suggesting that this was not a problem that required invention for it to be solved as of the Critical Date. Thus, a POSITA could easily access and choose from commercially available transducers, e.g., the ones disclosed in Rosener, and implement them in an earphone.

B. A POSITA would have had a reasonable expectation of success in implementing the two separate canalphones of the Rosener-Hankey combination.

16. Rosener discloses alternative techniques that could be used instead of the challenged converter-buffer technique disclosed in its paragraph [0039][1]. At

[1] The technique described in Rosener's paragraph [0039] is only one way that Rosener utilizes its buffer. Regardless of how paragraph [0039] may be read, Rosener still discloses a buffer for each of its earphones "to compensate data

least the alternative technique disclosed in paragraph [0040] of Rosener was well-known by the Critical Date. With this technique, "the data sample clock used by [the] RF transmitter" associated with the data source 618 is embedded "in the RF carrier signals used to carry the first and second data streams over the first and second wireless links 612, 616." APPLE-1004, ¶[0040]. "The subcarrier signals can be detected by the respective first and second RF receivers 604, 608 and converted into digital clocks which can drive the A/D converters of the first and second RF receivers 604, 608." *Id*.

17. Thus, even if a POSITA had difficulty implementing the A/D converter-buffer technique disclosed in paragraph [0039] of Rosener, they could easily benefit from the alternative technique of paragraph [0040]. Since modulating carrier signals with sample clocks at the transmitter side and demodulating the carrier signals to obtain the sample clocks were well-known techniques by the Critical Date, a POSITA would have a reasonable expectation of success in implementing this technique.

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packet losses." APPLE-1004, ¶[0037]. Therefore, I maintain my position with respect to claim 18 based on Rosener's disclosure in paragraphs [0037-42]. *See* APPLE-1003, ¶131 (discussing obviousness of claim 18).

C. Rosener's data source 922 is a microphone/sensor in an earphone.

18. The Patent Owner purports that Rosener is unclear as to whether data source 922 is a microphone/sensor in a headphone or a digital data source external to a headphone. Resp., 19-20. The Patent Owner bases its argument on my mistakenly identifying data source 922 as a digital source external to a headphone at the end of my four-hours deposition. *Id*.; KOSS-2037, 103:2-12. Rosener's clear disclosure slipped my eyes at the end of the deposition. A POSITA reading Rosener diligently, would have understood that the data source 922 in Rosener is a sensor/microphone incorporated within an earphone, which was my position in my Declaration as well. *See e.g.*, APPLE-1003, ¶120.

19. Rosener discloses system 600 that includes a data source 618 that sends audio streams (CH1 and CH2) to data sinks 602, 606 (which, together with the receivers 604 and 608, can correspond to earphones 502, 504). APPLE-1004, ¶¶[0031-36], FIG. 6. Rosener contemplates an arrangement in which each of receivers 604 and 608 of earphones 502, 504 is replaced by a transceiver 900 to thereby allow the earphone to both receive data for communication to a data sink 918 (e.g., speaker) and transmit data received from a data source 922 (e.g., a microphone). APPLE-1004, ¶¶[0030-36], [0049]. Thus, data source 922 is part of each earphone 502, 504.

20. Indeed, a POSITA would have understood what each term means in the context of the functions that the corresponding components perform. Rosener discloses that an earphone can have "a data source such as, for example, a sensor or microphone to allow a data to be sent back to an external electronic device." APPLE-1004, ¶[0056]. Considering that data source 922, which is part of each of earphones 502, 504, provides an input that is ultimately transmitted out of the earphone via antenna 906, a POSITA would have understood that data source 922 is the same as the microphone/sensor-type data source that Rosener contemplates for allowing "data to be sent back to an external device." *Id.*, ¶¶[0050] and [0056].

D. A POSITA would have had a reasonable expectation of success in using flexible circuit boards in the Rosener-Hankey combination earphones.

21. The Patent Owner purports that since during my deposition I did not "identify a suitable material for the flexible electrical connector in the proposed combination [of the art]," a POSITA "would have no reasonable expectation of success making wireless earphones…as proposed by Petitioner." Resp., 20. However, a POSITA would not need to know about the underlying materials for a building a circuit board in order to utilize one. Flexible circuit board were commercially available at the Critical Date. A POSITA could simply select from those commercially available flexible circuit boards without needing to know the

underlying material used in fabricating flexible circuit boards when implementing those boards in the Rosener-Hankey combination because the properties and characteristics of the boards were public knowledge at the Critical Date. Additionally, given the prevalence of materials used for flexible electrical connectors, a POSITA would have understood that a circuit board can be utilized and implemented into a system without requiring the POSITA to have specific knowledge about its underlying material.

22. Even if the underlying material was an issue, the POSITA could simply search for it in publicly available references. Methods of fabricating circuit boards were also well-known and public knowledge by that date. APPLE-1027, APPLE-1028, and APPLE-1029 are example references that described methods and materials for fabricating flexible circuit boards prior to the Critical Date.

A MICROPHONE IN EACH OF THE TWO EARPHONES

23. The Patent Owner alleges (i) that Rosener is "ambiguous at best on whether Rosener's earphones could each include a microphone," that (ii) even if Rosener's disclosure is read as "both earphones included the same type of data source, it would not be microphone." Resp., 21, 23 (emphasis in original). This is incorrect because Rosener explicitly discloses that "either or ***both*** the first and second data sinks of the various embodiments ***may include*** (or be coupled to) a

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,	)	
	)	
Petitioner,	)	Case IPR2021-00305
	)	Patent 10,506,325
vs.	)	
	)	Case IPR2021-00381
KOSS CORPORATION,	)	Patent 10,491,982
	)	
Patent Owner.	)	

The Zoom video deposition of JOSEPH McALEXANDER, III, taken before Richard Derrick Ehrlich, Registered Merit Reporter, Certified Realtime Reporter, taken pursuant to the United States Patent and Trademark Office Rules, commencing at 9:00 a.m., on the 14th day of December, 2021.

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I N D E X

E X H I B I T S

VIDEOGRAPHER: Good morning. We are going on the record. The time is 11:32 a.m. on December 14th, 2021.

This is Media Unit 1 of the video-recorded deposition of Joseph McAlexander, III, taken by counsel for the petitioner in the matter of Apple Inc. vs. Koss Corporation filed in the United States Patent and Trademark Office, Case No. IPR2021-00381 and IPR2021-00305.

This deposition is being held remote Zoom videoconference. My name is Justin Henricksen, and I'm from the firm Veritext, and I'm the videographer. The court reporter is Richard Ehrlich from the firm Veritext.

I'm not related to any party in this action, nor am I financially interested in outcome.

Counsel and all present in the room, everyone attending remotely will now state their appearances and affiliations for the record. If there are any objections to the proceedings, please state them at the time of your appearance beginning with the taking attorney first.

MR. PIEJA: Good morning. Michael Pieja of

Goldman Ismail on behalf of Apple, the petitioner in this action.

Also present on the line appearing on behalf of Apple are Jennie Hartjes of Goldman Ismail and Parvine Ghane and Roberto Devoto and Ryan Chowdhury of Fish & Richardson.

MR. KNEDEISEN: Mark Knedeisen from K & L Gates for patent owner Koss Corporation. I believe also on the line is Michelle Weaver from K & L Gates.

VIDEOGRAPHER: Thank you.

Will the court reporter please swear in the witness?

JOSEPH McALEXANDER, DEPONENT, SWORN

EXAMINATION

BY MR. PIEJA:

Q Good morning, Mr. McAlexander.

A I guess it still is. Good morning.

Q Indeed. I do apologize for the delay this morning, and I thank you for your patience and appreciate your taking the time to stick with us while we got those administrative issues sorted out.

Can you state your full name for the

record?
A Full name is Joseph Colby McAlexander, III.
Q Where are you sitting for your deposition today, sir?
A I'm sitting in my home office in Anna, Texas.
Q Is there anyone else present with you in the room where you're sitting for your deposition?
A No, sir. Nobody.
Q And are you communicating with anybody else via any apps on either your phone or your computer or any other electronic device as you sit there to take -- to sit for this deposition?
A No.
MR. KNEDEISEN: Let me just note, Michael, that I emailed -- sent him two emails with the exhibits.
MR. PIEJA: Absolutely. Thank you for the clarification, Mr. Knedeisen.
BY MR. PIEJA:
Q Mr. McAlexander, do you understand that you're here today to be deposed in -- with regard to declarations you submitted in connection with two IPR proceedings, IPR2021-305 and IPR2021-381?

Q Let's look at page -- paragraph -- excuse me -- 35 of your declaration with respect to the '982 patent. Let me know when you're there.
A Okay. I've got paragraph 35 in front of me.
Q Paragraph 35 of your '982 declaration discusses the Rosener reference, correct?
A That is correct.
Q And, of course, that Rosener reference is the same Rosener patent publication that we were talking about with respect to the '325 patent, correct?
A Correct.
Q In paragraph 35 of your declaration, you're discussing some of the components or types of components that can be used to implement the speaker in Rosener, correct?
A Yes, that's correct.
Q You list off several different types of speakers in paragraph 35 of your declaration, correct?
A That's correct.
Q These include a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of those transducer elements, correct?

A Correct.
Q And you then opine that each of these types of speakers or transducers has different properties and characteristics, correct?
A Yes, they do.
Q And you opine, I take it, that as a result of those different properties and characteristics, the different types of transducers that you describe in paragraph 35 are suited to different types of applications, correct?
A That would be correct, yes.
Q Where did you get the information that you recite in paragraph 35 about the differences in the properties and characteristics of the different types of transducers referenced there?
A Where do I get that information?
Q Yes, sir.
A Knowledge of working with acoustics and these types of transducers.
Q Now, each of the types of transducers that you describe in paragraph 35 was commercially available at the time of April 2008, correct?
A They would have been, yes.
Q As of April 2008, there was publicly available

information about the properties, characteristics, and uses of each of the types of transducers that you describe in paragraph 35, correct?
A I describe three types, as I recall, and so, yes, there was information about those three types.
Q By the way, does Rosener say that the three types of transducers you describe in paragraph 35 are the only types of transducers that can be used in its compact earphone?
A I don't recall him saying that they are the only ones, but they are the ones he describes. Let me check. One moment.
The ones that I identified in my first sentence on paragraph 35 is consistent with and overlays the statement out of paragraph 30 of Rosener.
So he says that the speaker may comprise, for example, and he lists these particular three. And so he is not excluding that there may be others, but these are the three that he addresses.
Q Rosener doesn't limit its disclosures to any of

US005733598A

United States Patent [19]

Sera et al.

[11] **Patent Number: 5,733,598**

[45] **Date of Patent: Mar. 31, 1998**

[54] **FLEXIBLE WIRING BOARD AND ITS FABRICATION METHOD**

[75] Inventors: **Naoki Sera**, Tsuyama; **Toshiharu Fukui**, Nara; **Kouji Tanabe**, Katano; **Futoshi Matsui**, Tsuyama, all of Japan

[73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka, Japan

[21] Appl. No.: **815,993**

[22] Filed: **Mar. 10, 1997**

Related U.S. Application Data

[60] Continuation of Ser. No. 463,988, Jun. 5, 1995, abandoned, which is a division of Ser. No. 132,036, Oct. 5, 1993, Pat. No. 5,461,202.

[30] **Foreign Application Priority Data**

Oct. 5, 1992	[JP]	Japan	4-265993
Nov. 30, 1992	[JP]	Japan	4-320230

[51] **Int. Cl.**^{6} **B05D 5/12**

[52] **U.S. Cl.** **427/96**; 427/98; 427/405

[58] **Field of Search** 427/96, 98, 282, 427/304, 383.1, 402, 405

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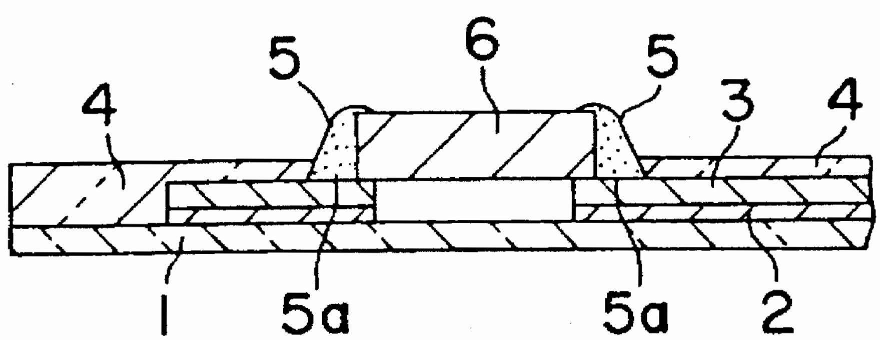
Primary Examiner—Michael Lusignan
Assistant Examiner—Brian K. Talbot
Attorney, Agent, or Firm—Ratner & Prestia

[57] **ABSTRACT**

A flexible wiring board includes a printed conductive circuit layer formed on an insulating film, a metallic layer formed on the printed conductive circuit layer, and an insulating layer formed on the metallic layer. A method of making a flexible wiring board includes the steps of forming a conductive circuit layer by screen printing a wiring pattern using a conductive paste, baking the printed wiring pattern, and forming a metallic layer on the printed conductive circuit layer by a plating method.

13 Claims, 10 Drawing Sheets



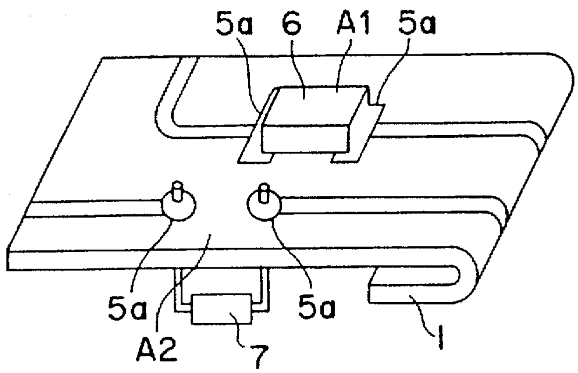


FIG. 1(a)

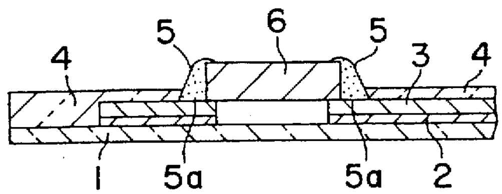


FIG. 1(b)

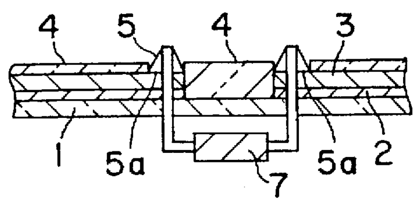


FIG. 1(c)

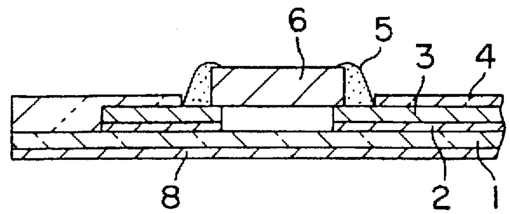


FIG. 2(a)

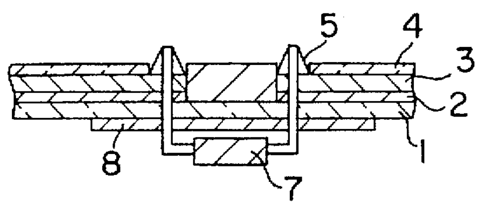


FIG. 2(b)

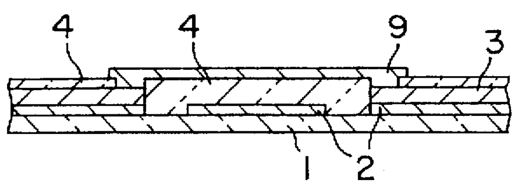


FIG. 3

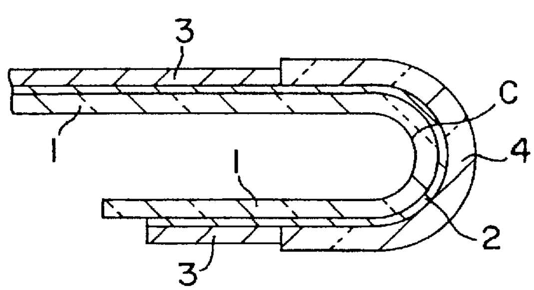


FIG. 4

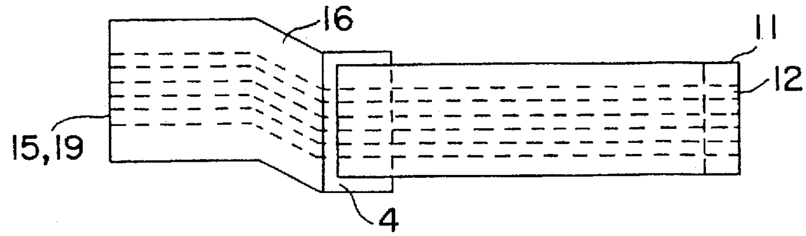


FIG. 5(a)

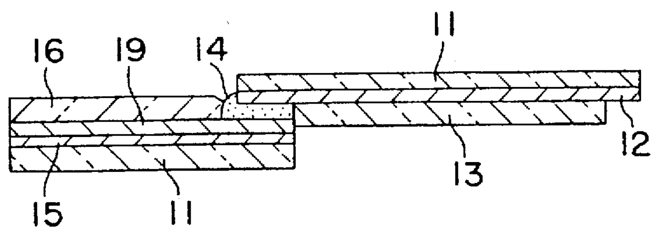


FIG. 5(b)

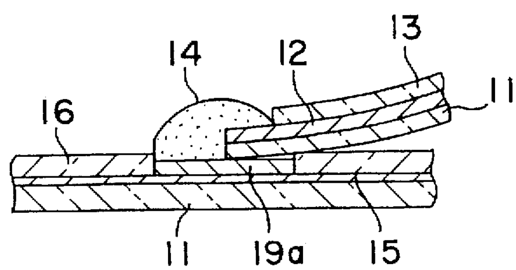


FIG. 6

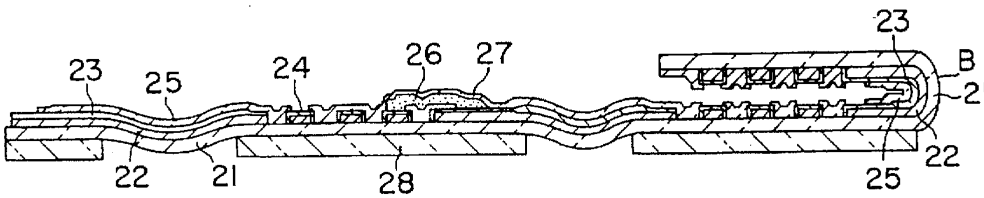


FIG. 7

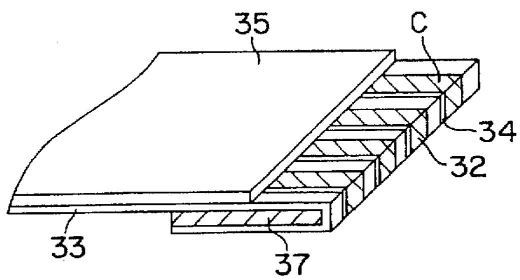


FIG. 8

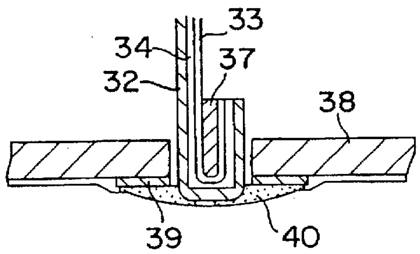


FIG. 9

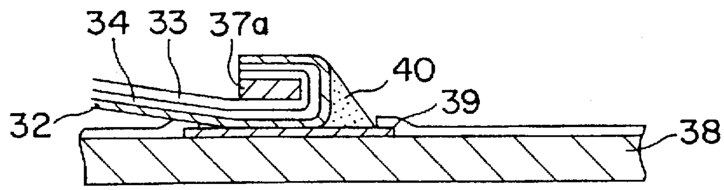


FIG. 10(a)

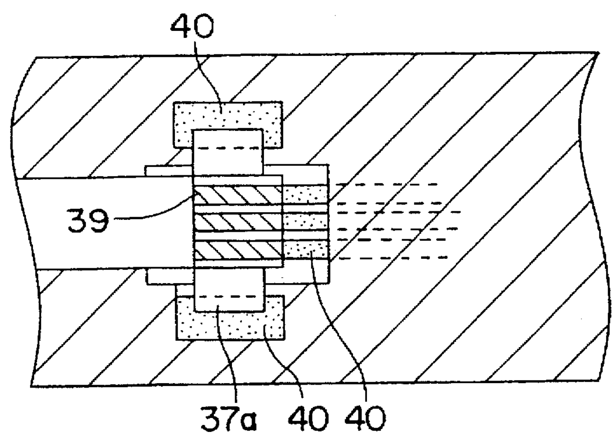


FIG. 10(b)

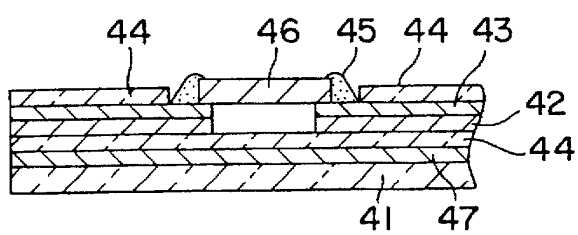


FIG. 11

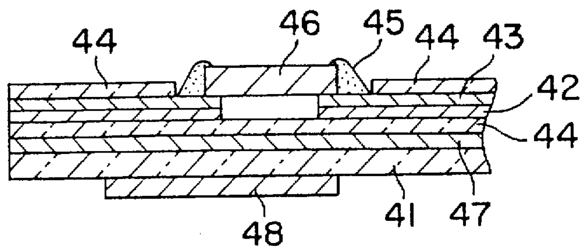


FIG. 12

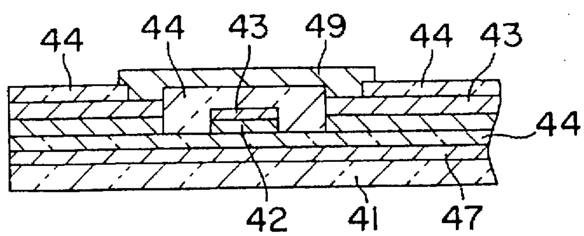


FIG. 13

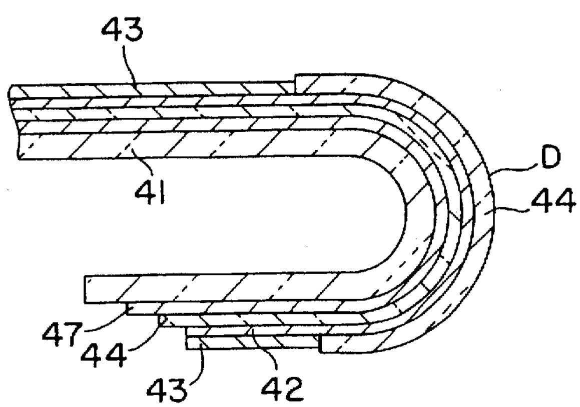


FIG. 14

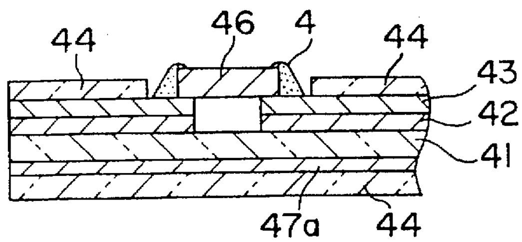


FIG. 15

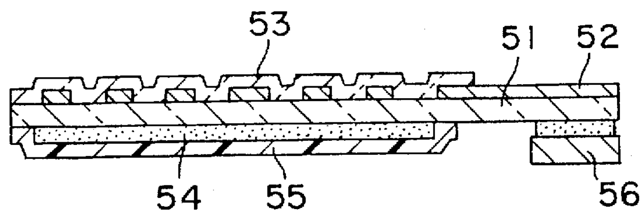


FIG. 16

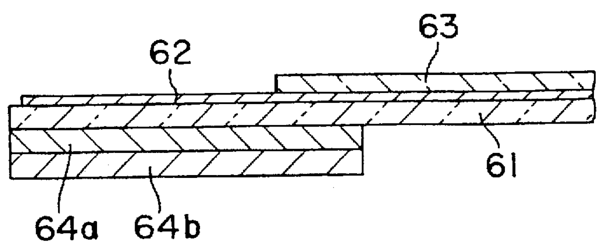


FIG. 17

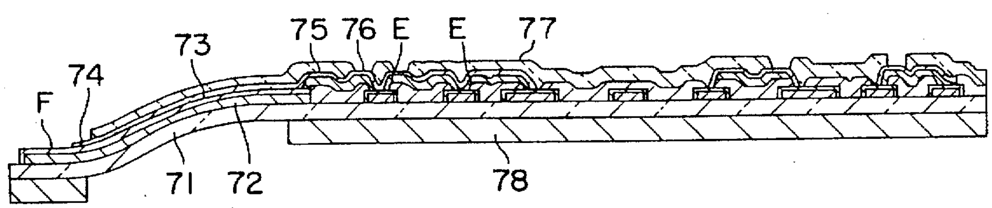
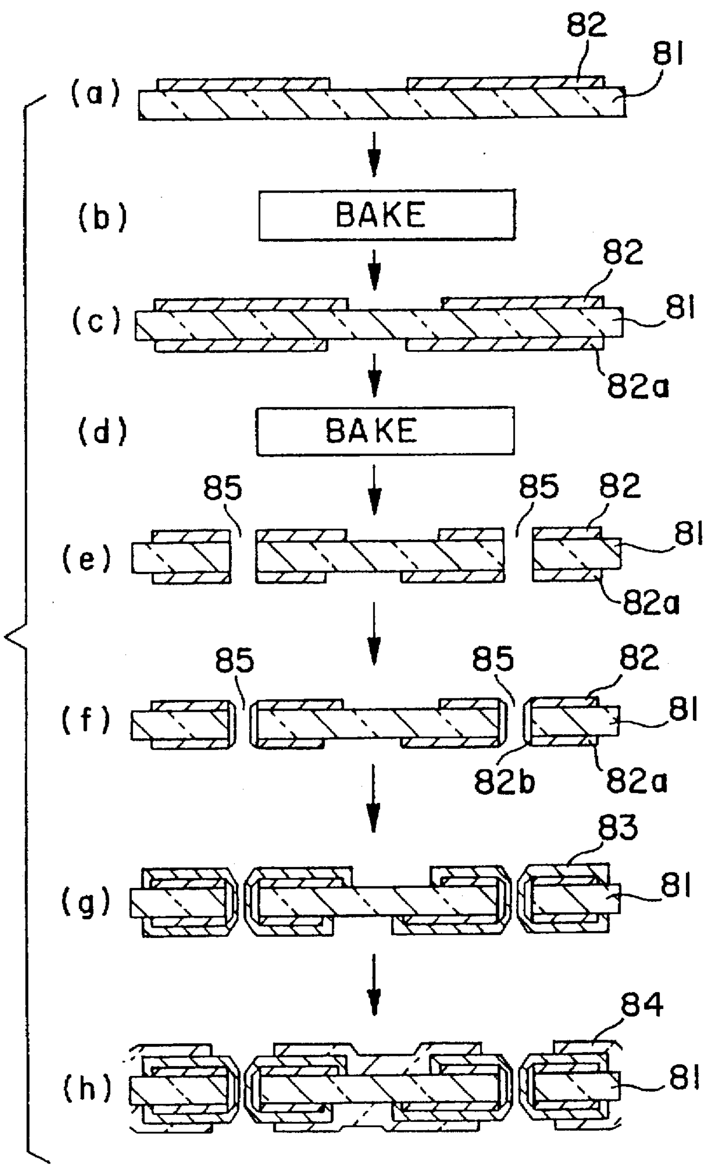


FIG. 18

FIG. 19



82
81
(a)
(b)
BAKE
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(c)
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BAKE
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(e)
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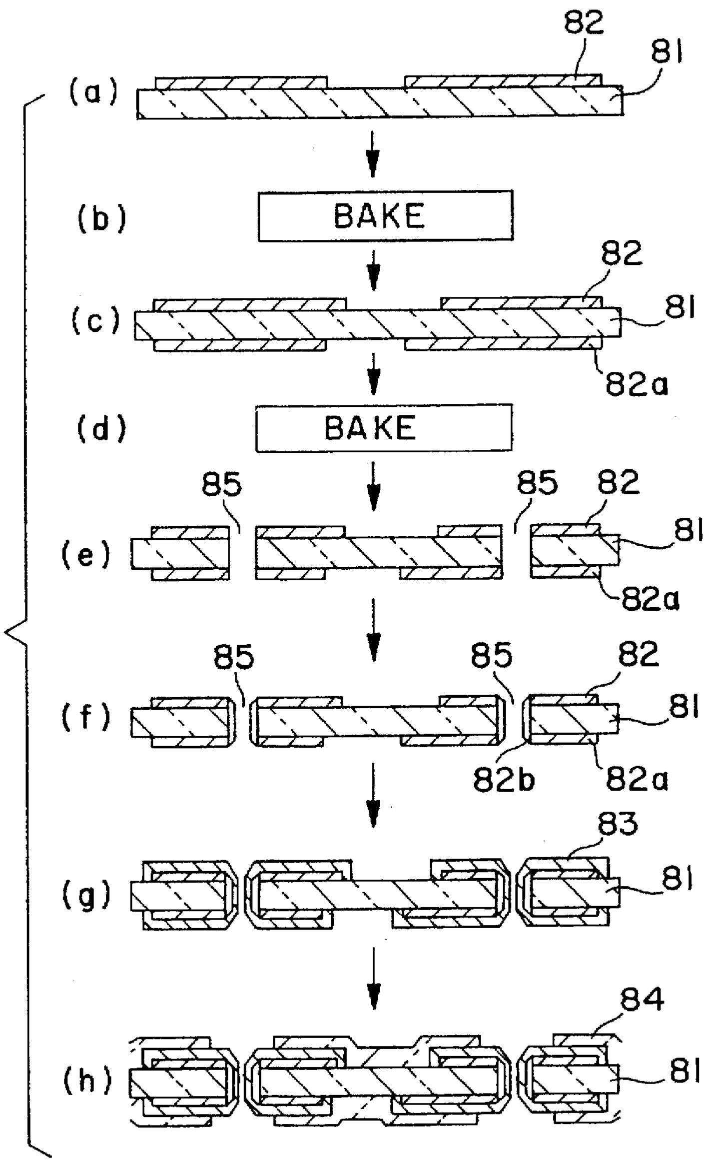
83
(g)
81
84
(h)
81

FIG. 20



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FLEXIBLE WIRING BOARD AND ITS FABRICATION METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of application Ser. No. 08/463,988 filed Jun. 5, 1995 now abandoned, which is a division of application Ser. No. 08/132,036, filed Oct. 5, 1993 now U.S. Pat. No. 5,461,202.

BACKGROUND OF THE INVENTION

The present invention relates to a flexible wiring board for use in operating panels of various kinds of electronic equipment and its fabrication method.

One method of the prior art flexible wiring board fabrication is removing unnecessary portions of copper foil by etching from a flexible board on which copper foil is pasted, and leaving circuit portions of the copper foil to form a conductive circuit.

Another method of the prior art flexible wiring board fabrication is by printing a circuit pattern on a flexible board with use of a conductive paste which was prepared by dispersing conductive powders such as a silver powder or the like into resin varnish and baking the printed pattern to complete a conductive circuit layer.

However, in the case of the flexible wiring board that uses copper foil, the disposition of the waste solution released from a etching process is costly and the environmental contamination problems caused by disposing harmful waster solution tend to become serious. Besides, the copper foil raises a question of insufficient durability against bending strains.

In the case of the flexible wiring board that uses a conductive paste to form a printed conductive circuit, there are questions of high resistance of the circuit pattern, inferior quality of the circuit, and poor solderability of the printed conductive circuit.

SUMMARY OF THE INVENTION

The present invention is intended for solving the aforementioned problems, and its object is to provide a flexible wiring board characterized by low resistance wiring circuits, good solderability, excellent durability against bending strains, or the like.

In addition to the foregoing, it aims at offering a method for fabricating flexible wiring boards, which features safety to the environment, low costs, or the like.

The flexible wiring board of the present invention is composed of a printed conductive circuit layer formed at specified places on an insulating film, a metallic layer formed on the printed conductive circuit layer, and an insulating layer formed on the metallic layer.

Also, the method for fabricating a flexible wiring board as disclosed by the present invention comprises the steps of forming wiring patterns at specified places on an insulating film by means of a screen printing using a conductive paste, forming a conductive circuit layer by baking the conductive paste, forming a metallic layer on the printed conductive circuit layer by means of a plating method, and forming an insulating layer on the metallic layer at places excluding at least lands for soldering.

The present invention makes it possible to bring about such effects as low resistance in the circuits, excellent conducting quality, easy soldering to the metallic layer formed on the printed conductive circuit layer, excellent durability against bending strains without causing breakage in the printed conductive circuit layer, no necessity of disposing the harmful waste solution produced from fabrication processes resulting in protection of the environment from contamination and reduced production costs due to simplified fabrication processes, or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**(*a*) is a perspective view of a flexible wiring board as a first exemplary embodiment of the present invention.

FIG. **1**(*b*) is a cross-sectional view cutting across an important area **A1** of the flexible wiring board as shown in FIG. **1**(*a*).

FIG. **1**(*c*) is a cross-sectional view cutting across an important area **A2** of the flexible wiring board as shown in FIG. **1**(*a*).

FIG. **2**(*a*) is a cross-sectional view of an important area of a flexible wiring board as a second exemplary embodiment of the present invention.

FIG. **2**(*b*) is a cross-sectional view of another important area of the flexible wiring board as the second exemplary embodiment of the present invention.

FIG. **3** is a cross-sectional view of a flexible wiring board as a third exemplary embodiment of the present invention.

FIG. **4** is a cross-sectional view of a flexible wiring board as a fourth exemplary embodiment of the present invention.

FIG. **5**(*a*) is a top plan view of a flexible wiring board as a fifth exemplary embodiment of the present invention.

FIG. **5**(*b*) is a cross-sectional view of a flexible wiring board as a fifth exemplary embodiment of the present invention.

FIG. **6** is a cross-sectional view of a flexible wiring board as a sixth exemplary embodiment of the present invention.

FIG. **7** is a cross-sectional view of a flexible wiring board as a seventh exemplary embodiment of the present invention.

FIG. **8** is a perspective view of a flexible wiring board as an eighth exemplary embodiment of the present invention.

FIG. **9** is a cross-sectional view to show an important area of a specific example wherein the flexible wiring board of the eighth exemplary embodiment of the present invention is used as a connector.

FIG. **10**(*a*) is a cross-sectional view of a flexible wiring board as a ninth exemplary embodiment of the present invention.

FIG. **10**(*b*) is a top plan view of the flexible wiring board as the ninth exemplary embodiment of the present invention.

FIG. **11** is a cross-sectional view of a flexible wiring board as a tenth exemplary embodiment of the present invention.

FIG. **12** is a cross-sectional view of a flexible wiring board as an eleventh exemplary embodiment of-the present invention.

FIG. **13** is a cross-sectional view of a flexible wiring board as a twelfth exemplary embodiment of the present invention.

FIG. **14** is a cross-sectional view of a flexible wiring board as a thirteenth exemplary embodiment of the present invention.

FIG. **15** is a cross-sectional view of a flexible wiring board as a fourteenth exemplary embodiment of the present invention.

FIG. **16** is a cross-sectional view of a flexible wiring board as a fifteenth exemplary embodiment of the present invention.

FIG. **17** is a cross-sectional view of a flexible wiring board as a sixteenth exemplary embodiment of the present invention.

FIG. **18** is a cross-sectional view of a flexible wiring board as a seventeenth exemplary embodiment of the present invention.

FIG. **19** shows the fabrication process for a flexible wiring board as an eighteenth exemplary embodiment of the present invention.

FIG. **20** shows the fabrication process for a flexible wiring board as a nineteenth exemplary embodiment of the present invention.

Key to Symbol

1, 11, 21, 41, 51, 61, 71, 81	Insulating Film
2, 15, 22, 42, 52, 62, 72, 82	Printed Conductive Circuit Layer
3, 19, 24, 43, 73, 83	Metallic Layer
4, 16, 23, 25, 44, 53, 63, 74, 84	Insulating Layer
12	Copper Conductor
28, 37	Reinforcement Plate
47	Printed Conductive Layer for Shielding
54	Printed Adhesive Layer
55	Printed Release Agent Layer
64a	Soft Reinforcement Material Layer
64b	Hard Reinforcement Material Layer
85	Material Layer Through Hole

DETAILED DESCRIPTION OF THE INVENTION

With the help of examples, the present invention is explained in detail.

EXAMPLE 1

A flexible wiring board is described as a first exemplary embodiment of the present invention with the help of FIG. **1**(*a*) through FIG. **1**(*c*). In FIG. **1**(*a*) to FIG. **1**(*c*), a printed conductive circuit layer **2** and a circuit pattern are disposed on one principal surface of an insulating film **1** by means of a screen printing method or the like. A metallic layer **3** is formed on the printed conductive circuit layer **2** by means of a plating method. An insulating layer **4** is disposed on the metallic layer **3** except it is not disposed on lands for soldering **5***a*. Solder **5** serves as a connecting means to join a chip component **6** and a leaded component **7** to the lands for soldering **5***a* formed of the metallic layer **3**.

In addition, the insulating layer **4** can also be disposed on the surface of the insulating film **1** where no metallic layer **4** is disposed as well as on metallic layer **3**.

The printed conductive circuit layer **2** is formed by means of a printed method using a conductive paste which is prepared by dispersing conductive powders of silver, copper palladium, or the like into resin or the like which has good adhesion to the insulating film **1**, and then baking the conductive paste. The resin used is polyester resin, epoxy resin, urethane resin or a modified resin thereof.

The metallic layer **3** is formed of copper, solder, nickel, gold, or the like disposed on the printed conductive circuit layer **2** by means of electroplating or electroless plating. The insulating layer **4** is formed mainly of a resin which has flexibility and good adhesion to the insulating film **1**. Such

resin is mainly formed of polyvinyl chloride resin, urethane resin, epoxy resin or a modified resin thereof.

The insulating film **1** used is polyimide, polyester, polyetherimide, polyether, etherketone, polysulfone, polyethersulfone, polyphenylene sulfide, or the like. The insulating layer **4** is formed by coating an insulating paste by means of a printed method, but it can also be formed by laminating insulating films. It is also possible to make a flexible wiring board which has the printed conductive circuit layer **2**, the metallic layer **3**, and the insulating layer **4** disposed not only on one surface of the insulating film **1**, but also has them disposed sequentially on the other surface of the insulating film **1**. It is further possible to make a flexible wiring board which has additionally a second printed conductive circuit layer, a second metallic layer, and a second insulating layer disposed sequentially on the insulating layer **4**. It is still further possible to make a multiple-layer flexible wiring board by having more than one of a flexible wiring board, which has the printed conductive circuit layer **2**, the metallic layer **3**, and the insulating layer **4** disposed on the insulating layer **1**, put together one over the other. As the means of putting the respective flexible wiring boards together, an adhesive or an adhesive sheet can be used. It is also possible to form the metallic layer **3** by means of a metal deposition method or other methods of disposing metallic thin films in addition to the plating method.

EXAMPLE 2

FIG. **2**(*a*) and FIG. **2**(*b*) illustrate the structure of a flexible wiring board as a second exemplary embodiment of the present invention. The difference of the flexible wiring board as described in FIG. **2** from that of FIG. **1** is in having a reinforcement plate **8** disposed on the bottom surface of the insulating film **1**. On account of the reinforcement plate **8**, the soldered portions and the vicinity thereof become stronger against the strains caused by bending. A film of polyester such as polyethylene terephthalate or the like, or a plate of aluminum or the like is used as the reinforcement plate **8**.

EXAMPLE 3

FIG. **3** shows the structure of a flexible wiring board as a third exemplary embodiment of the present invention. The difference from the flexible wiring board of FIG. **1** is in having a printed conductive circuit layer **9** used as a jumper disposed on the insulating layer **4**. The printed conductive circuit layer **9** used as a jumper is formed of a conductive paste which has good adhesion to the metallic layer **3** of the underneath circuit and is similar to the one used in Example 1.

EXAMPLE 4

FIG. **4** illustrates the structure of a flexible wiring board as a fourth exemplary embodiment of the present invention. The difference from the flexible wiring board of FIG. **1** is in having no metallic layer **3** disposed along the curved portions of the flexible wiring board of FIG. **4**. On account of this structure, a better performance against bending strains can be realized when compared with the flexible wiring board of FIG. **1**.

According to Example 1, the insulating layer **4** was formed by means of a printing method. However, the insulating layer **4** can also be formed by laminating insulating films.

According to Example 3, the printed conductive circuit layer **9** for jumper was formed by a conductive paste, but a

metallic layer can also be disposed over the printed conductive circuit layer **9** by means of a plating method.

As described in the foregoing, the flexible wiring boards of Example 1 through Example 4 have a structure including a printed conductive circuit layer **2**, which excels in adhesion and flexibility, disposed on an insulating film **1**, a metallic layer **3** disposed on the printed conductive circuit layer **2** by means of a plating method, and a flexible insulating layer **4** disposed on the surface of the metallic layer **3** except for the soldering lands **5***a* at a minimum.

On account of the foregoing structure, such features have better flexibility than that of the conductive circuit layer formed by means of a prior art etching method, good solderability due to the metallic layer **3**, and circuit resistance as low as that of the conductive circuits formed by means of an etching method can be realized. Besides, there is a benefit in realizing a low cost and making an excellent flexible wiring board by more simplified fabrication processes and by more effective utilization of resources when compared with the etching method.

Next, with the help of FIG. **5**(*a*) through FIG. **20**, the exemplary applications of the foregoing flexible wiring boards of the present invention will be explained as Example 5 to Example 19.

EXAMPLE 5

FIG. **5**(*a*) and FIG. **5**(*b*) show the structure of a flexible wiring board as a fifth exemplary embodiment of the present invention. As illustrated in the drawings, a printed conductive circuit layer **15** is disposed by patterning on an insulating film **11** by means of a screen printing method or the like. A metallic layer **19** is disposed on the printed conductive circuit layer **15** by means of a plating method. An insulating layer **16** is disposed on the surface of the metallic layer **19** except for the connecting area by a printing method. A soldering area **14** formed on a copper conductor **12**, which was formed by an etching method and covered with an insulating film **13** except for soldering area **14**, is for connection with the copper conductor **12** by soldering.

Polyimide resin or the like having high thermal resistance is used as the insulating film **13**. A copper clad polyimide board, wherein the polyimide insulating film and the copper conductor **12** are put together by lamination, is used as the aforementioned copper conductor **12** covered with the insulating film **13**.

Further, the printed conductive circuit layer **15** is formed of a conductive paste which is prepared by dispersing conductive powders of silver, copper, palladium or the like into a resin or the like that shows good adhesion to the insulating film **11**. The resin is polyester resin, epoxy resin, urethane resin or a modified resin thereof. The metallic layer **19** is formed of copper, solder, nickel, gold or the like disposed on the printed conductive circuit layer **15** by means of electroplating or electroless plating. The insulating layer **16** is mainly formed from a flexible resin such as polyvinyl chloride resin, urethane resin or epoxy resin, or a modified resin thereof which have good adhesion to the insulating film **1i**. The insulating film **11** used is polyimide, polyester, polyetherimide, polyetheretherketone, etherketone, polysulfone, polyethersulfone, polyphenylene sulfide or the like.

EXAMPLE 6

FIG. **6** shows the structure of a flexible wiring board as a sixth exemplary embodiment of the present invention. What differs in the present example from Example 5 shown in FIG. **5**(*a*) and FIG. **5**(*b*) is explained below. A metallic layer **19***a* is formed only at the connecting area, where a soldering area **14** is located, for securing durability against bending strains.

In the foregoing Example 5 and Example 6, the copper clad polyimide board formed of the copper conductor **12** is connected with the flexible wiring board of the present invention. The copper clad polyimide board having high thermal resistance facilitates is connected with component parts by soldering, and the connecting areas at both sides being metallic make it possible to connect by reliable soldering. This results in enhanced connecting reliability and also elimination of steps such as heat sealing or the like. The metallic layer **9** formed on the printed conductive circuit layer **15** by means of a plating method contributes to a reduction of wiring resistance. Additionally, the copper clad polyimide board is required to be used only at limited places with resultant contribution to realization of low cost and yet excellent flexible wiring boards.

EXAMPLE 7

FIG. **7** illustrates the structure of a flexible wiring board as a seventh exemplary embodiment of the present invention. In FIG. **7**, a printed conductive circuit layer **22** is disposed on the insulating film **21**. A first insulating layer **21** is formed selectively on the printed conductive circuit layer **22** and also on the surface of the insulating film **21** where conductive circuits are not formed. A metallic layer **24** is disposed on the printed conductive circuit layer **22**. A second insulating layer is provided. A second printed conductive circuit layer **26** is disposed on the printed conductive circuit layer **22** and metallic layer **24**. Another insulating layer **27** is provided. A reinforcement plate **28** is joined by adhesion with the insulating film **21**.

More specific aspects of Example 7 are explained here. The printed conductive circuit layer **22** is prepared by screen printing a specified pattern with use of a conductive paste (DX-121H made by TOYOBO) on an insulating film **21** formed of polyester film 75 μm thick, and then by baking at 150° C. for 30 minutes. The insulating layer **23** is disposed by screen printing with use of an insulating resist paste (FC-30G made by SHIKOKIKA-SEI), and then by baking at 150° C. for 30 minutes. The metallic layer **24** formed of copper of 15 μm thick and solder of 5 μm thick, is disposed by means of electroplating. Then, a different printed conductive circuit layer **26** is formed by screen printing in the same way as the printed conductive circuit layer **22** was formed, and then another different insulating layer **27** is formed by screen printing in the same way as the insulating layer **23** was formed to complete a multi-layer wiring structure. The reinforcement plate **28** is an aluminum sheet 1 mm thick.

In addition, the conductive paste for the printed conductive circuit layer **22** can be selected from the conductive pastes which were prepared by dispersing conductive powders of metals such as silver, copper, palladium or the like into resins such as polyester, epoxy, urethane or the modification thereof, all having good adhesion to the insulating film **1**. The metallic layer **24** can be formed of a metal selected from copper, solder, nickel, gold, or the like and disposed on the printed conductive circuit layer **22** by means of electroplating or electroless plating. The insulating layers **23**, **25** and **27** can be selected from materials which are flexible and mainly formed of rubber resin, vinyl resin, urethane resin, epoxy resin or a modified or mixed resin

thereof, all having good adhesion to the insulating film **21**. The material for the insulting film **21** can be polymide, polyester, polyetherimide, polyether-etherketone, polysulfone, polyethersulfone, polyphenylenesulfide, or the like.

The foregoing flexible wiring board as explained in Example 7 is characterized by disposing the printed conductive circuit layer **22**, which excels in adhesion and flexibility, on the insulating film **21**, forming the flexible insulating layer **23** on the area (area B) of the printed conductive circuit layer **22**, where good durability against bending strains is required, disposing the metallic layer **24** on the printed conductive circuit layer **22** by means of plating, and forming the flexible insulting layer **25** on the surface of the metallic layer **24** except for the connecting area of the soldering land.

Accordingly, the conductive circuit layer has better flexibility than the one formed by the prior art etching method, and soldering to the metallic layer **24** is made possible. Also, low wiring resistance almost equal to the resistance of the conductive circuit formed by etching can be realized. Further, a low cost and yet excellent flexible wiring board, which can benefit from simpler processes and better utilization of resources when compared with using the etching method, can be realized.

EXAMPLE 8

FIG. **8** illustrates the structure of a flexible wiring board as an eighth exemplary embodiment of the present invention. In FIG. **8**, a printed conductive circuit **34** is disposed on the insulating film **33**, a metallic layer **32** is formed on the printed conductive circuit **34**, an insulting layer **35** is provided, and a reinforcement plate **37** is held by squeezing between surfaces of the bent insulating film **33**. The printed conductive circuit layer **34** is formed by patterning on the insulating film **33** by means of a screen printing method or the like, the metallic layer **32** is disposed on the printed conductive circuit layer **34** by plating, and the insulating layer **35** is formed on areas except for a connecting terminal C. The reinforcement plate **37** is disposed in the space formed by bending the insulating film **33** to reinforce the connecting terminal C.

In addition, the printed conductive circuit layer **34** is formed of a conductive paste which was prepared by dispersing conductive powders metals such as silver, copper, palladium or the like into resins such as polyester, epoxy, urethane or the modification thereof, all having good adhesion to the insulting film **33**. The metallic layer **32** is formed of a metal selected from copper, solder, nickel, gold, or the like and disposed on the printed conductive circuit layer **34** by electroplating or electroless plating. The insulating layer **35** is mainly formed of materials which are flexible and have good adhesion to the insulating film **33**, such as vinyl resin, urethane resin, epoxy resin or a modified resin thereof. The materials for the insulating film **33** are polyimide, polyester, polyetherimide, polyether-etherketone, polysulfone, polyethersulfone, polyphenylenesulfide, or the like. The reinforcement plate is a polyester film, a phenol laminated board, a glass epoxy laminated board, an aluminum plate, or the like.

FIG. **9** shows a specific example wherein the terminal end of the flexible wiring board illustrated in FIG. **8** is used as a connecting means, and shows how the terminal end of the flexible wiring board can be soldered to a land **39** of a printed circuit board **38** by solder **40**.

EXAMPLE 9

A ninth exemplary embodiment of the present invention is explained with the help of FIG. **10**(*a*) and FIG. **10**(*b*). The explanation is made only on the points where Example 9 differs from Example 8. Item **37***a* is a reinforcement plate formed of a solderable metal such a aluminum, or the like, and the reinforcement plate **37***a* is also soldered to the land **39** of the printed circuit board **38** by the solder **40** to enhance the connecting strength.

Thus, the flexible wiring boards of Example 8 and Example 9 described in the foregoing have a structure wherein the reinforcement plate **37***a* is held by the bent connecting terminal C which makes it possible to provide a flexible wiring board which can be easily mounted on a printed circuit board.

EXAMPLE 10

A tenth exemplary embodiment of the present invention is explained with the help of FIG. **11**. In FIG. **11**, a printed conductive layer **47** for shielding is disposed on a insulating film **41** by means of screen printing or the like, and an insulating layer **44** is further disposed on the printed conductive layer **47** with another printed conductive circuit layer **42** formed by patterning on the insulating layer **44** by means of a screen printing method or the like. Item **43** is a metallic layer disposed on the printed conductive circuit layer **42** by means of plating, and further the insulating layer **44** is disposed on the areas surrounding the soldering land situated on the metallic layer **42**. A soldered area **45** fixes a component part **46** by soldering to the land formed of metal.

In addition, the printed conductive circuit layer **42** and the printed conductive circuit layer **47** for shielding are formed of a conductive paste which was prepared by dispersing conductive powders of metals such as silver, copper, palludium or the like into resins such as polyester, epoxy, urethane or a modification thereof, all having good adhesion to the insulating film **41** and insulating layer **44**. The metallic layer **43** is formed of a metal selected from copper, solder, nickel, gold, or the like and disposed on the printed conductive circuit layer **42** by means of electroplating or electroless plating.

The insulating layer **44** is mainly formed of materials, which are flexible and have good adhesion to the insulating film **41**, such as vinyl resin, urethane resin, epoxy resin or a modified resin thereof.

The insulating film **41** material is polyimide, polyester, polyetherimide, polyetheretherketone, polysulfone, polyethersulfone, polyphenylenesulfide, or the like.

In addition, it is possible to make a flexible wiring board comprising a printed conductive circuit layer **42** disposed on one principal surface of an insulating layer **41**, a metallic layer **43** having a soldering land formed on the printed conductive circuit layer **42** by means of plating, an insulating layer **44** disposed on the surface of the metallic layer **43** except for the area where the soldering land is located, a printed conductive layer for shielding disposed on the insulating layer **44**, and a second insulating layer formed on the conductive layer for shielding.

EXAMPLE 11

FIG. **12** illustrates the structure of a flexible wiring board as an eleventh exemplary embodiment of the present invention,

Only the differences between the present example and Example 10 are explained below.

The difference from foregoing Example 10 is that a reinforcement plate **48** is disposed on the bottom surface of the insulating film **41**.

The reinforcement plate strengthens the soldered places or the like against bending strains. The reinforcement plate **8** is a polyester film such as ethylene terephthalate or the like, or an aluminum plate or the like.

EXAMPLE 12

FIG. **13** illustrates the structure of a flexible wiring board as a twelfth exemplary embodiment of the present invention. Only the differences between the present example and Example 10 are explained below.

The difference from foregoing Example 10 is that a printed conductive circuit layer **48**, serving as a jumper crosses over the metallic layer **43**, disposed on the insulating layer **44**.

EXAMPLE 13

FIG. **14** illustrates the structure of a flexible wiring board as a thirteenth exemplary embodiment of the present invention.

Only the difference between the present example and Example 10 are discussed below.

The difference from foregoing Example 10 is that a curved section D is formed as well as a metallic layer **43**. Metallic layer **43**, is not formed on the curved section D area. This construction ensures excellent durability against bending strains. Metallic layer **43** is formed plating.

EXAMPLE 14

FIG. **15** illustrates the structure of a flexible wiring board as a fourteenth exemplary embodiment of the present invention.

The differences between the present example, and Example 10 is provided below.

The difference from Example 10 is that a conductive layer **47*a*** serving as a shield is formed on a surface of the insulating film **41** opposite to the surface where the printed conductive circuit layer **42** is disposed instead of on the same side. An insulating film **44** is also formed on the conductive layer **47*a***.

The conductive layer **47*a*** may be form by plating.

As described in Example 10 to Example 14, by having the conductive layer **47** or the conductive layer **47*a***, serving as a shield, it has become possible to provide a flexible wiring board which is low in cost and excellent in shielding effects.

EXAMPLE 15

A fifteenth exemplary embodiment of the present invention is explained with the help of FIG. **16**.

In FIG. **16**, a printed conductive circuit layer **52** is disposed on an insulating film **51** with a cover coat insulating layer **53** superimposed on the printed conductive circuit layer **52**.

On the bottom surface of the insulating film **51** a printed layer of adhesive material **54** is disposed on the bottom surface of the insulating film **51**, a printed layer of mold release material **55** is disposed on the printed layer of adhesive material **54**, and a reinforcement plate **56** is attached by adhesion onto the printed layer of adhesive material **54** in the same way.

After screen printing a specified pattern on a polyester insulating film **51** of a work size measuring 500 ×300 mm and a thickness of 75 ϕm with a conductive paste (DX-121H of TOYOBO), a conductive circuit layer **52** was forced by baking at 150° C. for 30 minutes.

An insulating layer **53** was formed by baking at 150° C. for 30 minutes after screen printing with an insulating resist paste (XB803A of FUJIKURA KASEI).

Then, a screen printing was applied to the bottom surface of the film with the use of an adhesive paste (UPA-046 of FUJIKYRA KASEI) and the printed adhesive was hardened by irradiation of ultra-violet light to form an adhesive material layer **54**, and further a screen printing of mold release masking tape (TB-3044 of THREE BOND) was applied and irradiated with ultraviolet light to form a layer of mold release material **55**.

After working on the external shape of the flexible wiring board, the layer of mold release material **55** was peeled off, and then a 1 mm thick aluminum plate was attached to the layer of adhesive material **54** to form a reinforcement plate **56**.

The adhesive material used in the adhesive material layer **54** of the aforementioned example can be selected according to the required adhesion strength from vinyl resins such as polyvinyl chloride, vinyl acetate, or the like, rubber resins such as chloroprene-rubber, nitrile-rubber, natural rubber, or the like, such other resins as acrylic, polyolefin, urethane, polyester, epoxy and silicone resins, and the copolymer and blend resins thereof.

The equipment for baking is selected from a solvent drying type, a thermosetting type, a UV curing type, or the like according to the required resin baking system.

Any materials can be used for the mold release material **55** provided such materials have an appropriate releasing capability since those materials are secondary in importance to enhance the performance of the flexible wiring boards.

The reinforcement plate **56**, can be a soft plate such as a polyester plate, or the like, or a hard plate such as an aluminum plate, or the like.

Generally, in the case of soft plates, a reinforcement plate coated in advance with an adhesive material is placed by adhesion on a flexible wiring board before the board is subjected to machining of its outline configuration, and the flexible wiring board and the reinforcement plate may be together processed by machining the outline configuration thereof.

In place of having the mold release material printed on the reinforcement plate after printing of the adhesive material, the mold release material may be placed by adhesion on the plate.

In the aforementioned example, the adhesive material layer **54** can be disposed on the surface of the insulating layer **53**. In this case, the mold release material layer **55** is formed on the insulating layer **51**.

Although a flexible wiring board using a printed conductive circuit layer **52** was explained in the foregoing example, the method employed is equally effective wherein the conductive circuit wiring is the most widely used copper foil etched wiring or, a double-sided wiring, or a multiple-layer wiring.

All the foregoing kinds of wiring are, as a matter of coarse, covered by the present invention.

Also, it is possible in the foregoing example to dispose other flexible wiring layers on the adhesive material layer **54** to form a multiple-layer wiring board.

According to the foregoing example, an adhesive material layer and a mold release material layer can be formed together by printing on the upper or bottom surface of a flexible wiring board of a work size for printing, resulting in very efficient production work.

Additionally, there is no loss in materials due to the screen printing of the adhesive material and the mold release material which are in a paste-like state. Also, there is no problem of wrinkles, since process of sheet placing is not involved.

Further, a preparatory processing of the outline shape required of the double-sided adhesive sheet and its molding dies are no longer needed.

Additionally, there is no need in using a connecting part like the double-sided adhesive sheet for multiple molding. This contributes to preventing the adhesive paste from sticking to the molding dies at the time the outline shape processing of the flexible wiring board, and contributes to the elimination of the cleaning process frequently required of the molding dies.

Regardless of the form of the insulation film, a role form or a sheet form, the adhesive material and the mold release material can be, in practice, disposed by a continuous printing process with the respective printing machines interconnected, making it possible to enhance the productivity and to prevent the troubles caused by the stickiness of the adhesive material.

EXAMPLE 16

FIG. **17** illustrates the structure of a flexible wiring board as a sixteenth exemplary embodiment of the present invention.

In FIG. **17**, a printed conductive circuit layer **62** is disposed on a insulating film **61**. An insulating layer **63** is formed on the printed conductive circuit layer **62** so that the end part of the printed conductive circuit layer **62** is left uncovered.

The exposed portion of the foregoing printed conductive circuit layer **62** may be disposed with a metallic layer by means of plating.

A soft reinforcement material layer **64***a* is disposed on the end part of the bottom surface of the insulating film **61**.

A hard reinforcement material layer **64***b* is disposed on the soft reinforcement material layer **64***a*.

A connected terminal is disposed on the end of on the flexible wiring board.

Example 16 is described is detail below.

After screen printing a specified pattern on a polyester insulating film **61** of a work size measuring 500 ×300 mm and a thickness of 75 μv using a conductive paste (DX-121H of TOYOBO), a conductive circuit layer **62** was formed by baking at 150° C. for 30 minutes. An insulating layer **63** was formed by baking at 150° C. for 30 minutes after screen printing with an insulating resist paste (XB-803A of FUJIKURA KASEI). Then, a screen printing was applied to the end part of the bottom surface of the film with use of a soft reinforcement material paste (P-170 of CEMEDYNE/isophorone as diluting solvent, 5 wt. %), and the reinforcement material paste was hardened at 150° C. for 30 minutes to complete the soft reinforcement material layer **64***a*. On the soft reinforcement material layer **64***a* was superimposed by screen printing a hard reinforcement material paste (47.5 wt. % of EP-170 of CEMEDYNE/47.5 wt. % of EP-171 of CEMEDYNE/5 wt. % of isophorone as diluting solvent), and then the reinforcement material paste was hardened at 150° C. for 30 minutes to complete the hard reinforcement material layer **64***b*. The combined thickness of the soft reinforcement material layer **64***a* and the hard reinforcement material layer **64***b* was 200 μm.

A connector engagement and disengagement test was conducted both on the flexible wiring board of the present example and a prior art flexible wiring board having a reinforcement plate of a 180 μm thick polyethylene terephthalate film covered by a 20 μm thick adhesive material attached by adhesion. According to the test result, while the printed conductive circuit layer **62** of the prior art flexible wiring board was worn out after 20 times of the engagement and disengagement of a connector, the printed conductive circuit layer **62** of the flexible wiring board disposed with the reinforcement layers **64***a* and **64***b* according to the foregoing example was worn out after 50 times of the engagement and disengagement of the connector.

The reinforcement material can be selected according to the required strength from vinyl resins such as polyvinylchloride or the like, rubber resins such as chloroprene-rubber, nitrile-rubber, natural rubber or the like, such other resins as acrylic, polyolefin, urethane, polyester, epoxy and silicone resins or the like, the copolymer resins thereof, or the blend resins thereof.

Although a flexible wiring board using a printed conductive circuit layer **62** was explained in the foregoing example, the method employed is equally effective where the conductive circuit wiring is the most widely used copper foil etched wiring, a double-sided wiring, or a multiple-layer wiring. All of the foregoing kinds of wiring are, as a matter of course, covered by the present invention.

According to the foregoing example, numerous reinforcement material layers **64***a* and **64***b* can be formed together by printing at specified areas of a flexible wiring board of a work size for printing, resulting in very efficient production work.

Additionally, there is no loss in materials due to screen printing of the reinforcement material which is in a paste-like state. There is no problem of wrinkles either, since no process of sheet placing is involved. Further, coating of the adhesive material on the reinforcement sheet, preparatory processing of the outline shape and its molding dies are no longer needed. Therefore, there is no danger of the adhesive paste sticking to the molding dies during the outline shape processing of the flexible wiring board, and therefore no need for the frequent cleaning of the molding dies which was required before.

Further, the durability of the end part of the printed conductive circuit layer against the connector's engagement and disengagement operation is greatly enhanced when the reinforcement material layer is composed of two printed layers, first printed with a soft material and second with a hard material.

EXAMPLE 17

FIG. **18** illustrates the structure of a flexible wiring board as a seventeenth exemplary embodiment of the present invention. In FIG. **18**, a first printed conductive circuit layer **72** is formed on the insulating film **71** by screen printing with the use of a conductive paste. A first metallic layer **73** is disposed on the conductive circuit layer **72** by means of a plating method. A first flexible insulating layer **74** is disposed by screen printing with use of an insulating paste on the surface of the first metallic layer **73** except for the areas where a through-hole land E and an external connection terminal F are located and on the insulating film **71**. On the insulating layer **74** is, disposed by screen printing with use of a conductive paste, a printed conductive circuit layer **75** which is connected with the through-hole land E. On the conductive circuit layer **75** is formed by means of a plating method a second metallic layer **76**. A second insulating layer **77** is disposed by screen printing on the second metallic

layer **76** except for the area where the external connection terminal F is located. Further, a reinforcement plate **78** is disposed on the bottom surface of the insulating film **71**. Accordingly, the flexible wiring board of the present example is fabricated by the steps of forming by patterning the insulating layer **74** on the first metallic layer **73** and on insulating film **71** with the through-hole land E exposed without being covered by the insulating layer **74**, disposing the printed conductive circuit layer **75** to connect with the through-hole land E, and further forming the second metallic layer **76** on the printed conductive circuit layer **75**.

Details of the foregoing example are explained below. After screen printing with use of a silver paste (DX-121H of TOYOBO), conductive circuit layers **72** and **75** were formed by baking at 150° C. for 30 minutes. The conductive paste for the printed conductive circuit layers **72** and **75**, can also be formed by a conductive paste prepared by dispersing conductive powders of metals such as silver, copper, palladium or the like into polyester resin, epoxy resin, urethane resin, the modified resins thereof or the like, all having good adhesion to the insulating film or the insulating layer **77**. The metallic layers **73** and **76** are composed of metals such as copper, solder nickel, gold or the like that were disposed on the printed conductive circuit layer **72** by means of electroplating or electroless plating.

In the foregoing example, the metallic layer **73** was formed of copper to a thickness of 15 μm by electroplating. The second metallic layer **76** was formed of copper to a thickness of 10 μm, and of solder to a thickness of 5 μm thereon, both by electroplating. The insulating layers **74** and **77** were formed by screen printing with use of a flexible insulating ink (FC-30G of SHIKOKU KASEI), and then by baking at 150° C. for 30 minutes. These insulating layers **74** and **77** are flexible and principally composed of rubber resins, vinyl resins, urethane resins, epoxy resins, the modified resins thereof, or the blend resins thereof, all having good adhesion to the insulating film **71**, and the metallic layers **73** and **76**. The material for the insulating film **41** can also be polyimide, polyester, polyetherimide, polyetheretherketone, polysulfone, polyphenylenesulfide, or the like.

In the foregoing Example 17, it is also possible to fabricate a multiple-layer circuit by first disposing a third printed conductive circuit layer on the insulating layer **77** in connection with the other metallic layer **76** formed on the through-hole land E, and then disposing a third metallic layer on the third printed conductive circuit layer by means of a plating method.

According to the foregoing example, it is possible to provide a multiple-layer flexible wiring board which is characterized by such excellent effects as the conductive circuit layer having more excellent flexibility than that formed by the prior art etching method, the metallic layer **73** which is solderable, realization of wiring resistance that is as low as the wiring resistance of the conductive circuit formed by etching, a much more simplified fabrication process when compared with the fabrication process using an etching method, the more effective utilization of the resources, and realization of reduction in costs.

EXAMPLE 18

FIG. **19**(*a*) to FIG. **19**(*h*) illustrate the fabrication processes of a flexible wiring board of the present invention. The flexible wiring board illustrated is a double-sided type. In the illustrations, the different layers are an insulating film **81**, a printed conductive circuit layer **82**, a metallic layer **83**, an insulating layer **84**, and a through-hole **85**. An explanation on each respective step of the fabrication processes follows. FIG. **19**(*a*) shows the step of pattern forming the printed conductive circuit layer **82** at specified places on one principal surface of the insulating film **81** by means of a screen printing method using a conductive paste. FIG. **19**(*b*) is the step of baking the conductive paste printed on the insulation film **81**. FIG. **19**(*c*) is the step of disposing by patterning a printed conductive circuit layer **82*a*** on the other surface of the insulating film **81** by means of a screen printing method using a conductive paste. FIG. **19**(*d*) is the step of baking the printed conductive paste. FIG. **19**(*e*) is the step of boring the through-holes **85** at specified areas on the insulating film on which the printed conductive circuit layer is disposed. FIG. **19**(*f*) is the step of forming a conductive circuit layer **82*b*** by applying a conductive paste to the through-holes **85**, and then by baking the conductive paste. FIG. **19**(*g*) is the step of disposing the metallic layer **83** on the conductive circuit layers **82**, **82*a*** and **82*b*** by plating. FIG. **19**(*h*) is the step of forming the insulating layer **84** on the surface of the metallic layer **83** except for the connecting areas of the soldering lands, and also on the surface of the insulating film **81** where no metallic layer is disposed.

In addition, it is possible to apply, by printing in the foregoing fabrication processes, the conductive paste to both surfaces of the insulating film **81**, and then baking the conductive paste.

The printed conductive circuit layers **82**, **82*a*** and **82*b*** are formed of a conductive paste prepared by dispersing conductive powders of metals such as silver, copper, palladium or the like into polyester resin, epoxy resin, urethane resin, the modified resins thereof or the like, all having good adhesion to the insulating film **81**. The metallic layer **83** is composed of metals such as copper, solder, nickel, gold or the like that are disposed on the printed conductive circuit layer **82** by means of electroplating or electroless plating.

The insulating layer **84** is principally composed of vinyl chloride resin, urethane resin, epoxy resin, the modified resins thereof, all of which have flexibility and good adhesion to the insulating film **81**. The material for the insulating film **81** is polyimide, polyester, polyetherimide, polyetheretherketone, polysulfone, polyethersulfone, polyphenylenesulfide, or the like.

EXAMPLE 19

FIG. **20**(*a*) to FIG. **20**(*g*) illustrate the fabrication processes of a flexible wiring board as a nineteenth exemplary embodiment of the present invention. In the illustrations, the same portions as illustrated in FIG. **19** are referred to by the same numerical symbols as used in FIG. **19**. FIG. **20**(*a*) shows the step of boring the through-holes **85** at specified areas on the insulating film **81**. FIG. **20**(*b*) shows the step of pattern forming the printed conductive circuit layer **82** on one principal surface of the insulating film **81**, where the through-holes **85** are located, by means of a screen printing method using a conductive paste. FIG. **20**(*c*) is the step of baking the conductive paste printed on the insulation film **81**. FIG. **20**(*d*) is the step of disposing by patterning a printed conductive circuit layer **82*a*** on the other surface of the insulating film **81** by means of a screen printing method using a conductive paste. FIG. **20**(*e*) is the step of baking the printed conductive paste. FIG. **20**(*f*) is the step of disposing the metallic layer **83** on the conductive circuit layers **82** and **82*a*** by plating. FIG. **20**(*g*) is the step of forming the insulating layer **84** on the surface of the metallic layer **83** except for the soldering lands.

The insulating layer **84** can be disposed not only on the surface of the metallic layer **83**, but also on the surface of the insulating film **81** where no metallic layer **83** is disposed.

In the steps for conductive paste printing as illustrated in FIG. **20**(*b*) and FIG. **20**(*d*), the conductive paste is printed on the surfaces of the through-holes **85**, too. Accordingly, through-holes having conductivity have been fabricated.

In addition, a reinforcement plate formed of a polyester film, a phenolic laminated board, a metallic plate, or the like can also be disposed at a place where reinforcement is required. By disposing another printed conductive circuit layer on the insulating layer, it is also made possible to fabricate a double sided flexible wiring board of multiple layer circuits.

According to the foregoing Examples **18** and **19**, the method of fabrication of a flexible wiring board of the present invention comprises the steps of forming a printed conductive circuit layer **82**, which excels in adhesion and flexibility, on an insulating layer **81** by means of a screen printing method of excellent mass-producibility, forming a metallic layer **83** on the printed conductive circuit layer **82** by plating, and disposing a flexible insulating layer **84** on the metallic layer **83** except for the connecting areas of soldering lands.

The fabrication method as disclosed by the present invention makes it possible to realize an excellent flexible wiring board which is characterized by such features as a conductive circuit layer with more excellent flexibility than the one formed by the prior art etching method, a metallic layer **83** which is solderable, realization of wiring resistance that is as low as the wiring resistance of a conductive circuit formed by etching, a much simplified fabrication process when compared with the fabrication method of an etching method, more effective utilization of the resources, reduced costs, or the like.

According to the present invention, it is also possible to use a method of coating an insulating paste and baking it or a method of laminating insulating films by adhesion as the method of forming an insulating layer.

As described in the foregoing, the present invention provides such effects as securing excellent conductivity with reduced wiring resistance by forming a metallic layer on a printed conductive layer formed by means of a printing method using a conductive paste, providing a metallic layer which is readily solderable, assuring environmental safety with no necessity of the disposition of waste solution associated with the prior art etching method using copper foils, realization of reduced costs on account of simplified fabrication processes, or the like.

Accordingly, the prior art flexible wiring board which used copper foils for the conductive circuit layer would break after being bent several times. In contrast, a flexible wiring board of the present invention having a printed conductive circuit layer, has good durability against bending strains as indicated by an experiment wherein the printed conductive circuit layer does not show any breakage even if the metallic layer is broken.

What is claimed:

1. A fabrication method for flexible wiring boards comprising the steps of:

(a) forming a printed conductive circuit layer on a flexible insulating film,

(b) plating a metallic layer on said printed conductive circuit layer,

(c) forming an insulating layer on a portion of said insulating film and on at least a portion of said metallic layer; and

(d) obtaining said flexible wiring board as a result of steps (a), (b), and (c).

2. A fabrication method for flexible wiring boards according to claim **1**, wherein the insulating layer is formed by a printing method using an insulating paste.

3. A fabrication method according to claim **1**, wherein the insulating layer is a substrate.

4. A fabrication method for flexible wiring boards according to claim **1**, wherein the insulating layer is formed by a laminating method using insulating materials.

5. A fabrication method for flexible wiring boards according to claim **1**, wherein said insulating layer is formed mainly of a resin which has flexibility.

6. A fabrication method for flexible wiring boards according to claim **1**, wherein said printed conductive circuit layer is formed using a conductive paste which is comprised of dispersing conductive powders and resin.

7. A fabrication method for flexible wiring boards according to claim **1**, wherein said first metallic layer is at least one selected from the group consisting of copper, solder, nickel and gold.

8. A fabrication method for flexible wiring boards according to claim **1**, wherein said flexible insulating film is a plastic film.

9. A fabrication method for flexible wiring boards according to claim **1**, wherein said flexible insulating film is a resin.

10. A fabrication method for flexible wiring boards comprising the steps of:

(a) screen printing a specified wiring pattern on a first portion of a flexible insulating film using a conductive paste;

(b) forming a printed conductive circuit layer by baking said wiring pattern;

(c) plating a metallic layer on said printed conductive circuit layer;

(d) forming an insulating layer using a printing method on a second portion of said insulating film and on at least a first portion of said metallic layer; and

(e) obtaining said flexible wiring board as a result of steps (a), (b), (c), and (d).

11. A fabrication method according to claim **10**, wherein the insulating layer is a substrate.

12. A fabrication method for flexible wiring boards comprising the steps of:

(a) screen printing a specified wiring pattern on a first portion of a flexible insulating film using a conductive paste;

(b) forming a first printed conductive circuit layer by baking said wiring pattern;

(c) plating a first metallic layer having a plurality of through-hole lands and external connection terminals on said first printed conductive circuit layer;

(d) forming an insulating layer on said first metallic layer so that said through-hole lands are exposed;

(e) screen priming a second printed conductive circuit layer on said insulating layer and in contact with said through-hole lands on said first metallic layer;

(f) plating a second metallic layer on said second printed conductive circuit layer; and

(g) obtaining said flexible wiring board as a result of steps (a) through (f).

13. A fabrication method according to claim **12**, wherein the insulating layer is a substrate.

* * * * *

UNITED STATES PATENT AND TRADE MARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,733,598
DATED : March 31, 1998
INVENTOR(S) : Sera et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Cover page, item [56] References Cited, U.S. Patent Documents,
"4,559,357 12/1985 Matsumoto" should be --4,550,357 10/85 Matsumoto--.

Column 16, line 57, "priming" should be --printing--.

Signed and Sealed this

Tenth Day of November 1998

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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APPLE INC., :

Petitioner, :

v. : Case No. IPR2021-00381

KOSS CORPORATION, :

Patent Owner. : U.S. Patent No. 10,491,982

\- - - - - - - - - - - - - - x

REMOTE DEPOSITION of JEREMY COOPERSTOCK, Ph.D.

Monday, September 13, 2021

9:28 a.m. CST

Job No.: 394208

Pages: 1 - 109

Reported By: Michelle M. Yohler, CSR, RMR, CRR

The deposition of JEREMY COOPERSTOCK, Ph.D., held remotely pursuant to notice before Michelle M. Yohler, CSR, RMR, CRR, a certified shorthand reporter, CSR No. 84-4531.

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E X A M I N A T I O N S

E X H I B I T S

(Retained by counsel.)

P R O C E E D I N G S

(Technician read-on.)

*** *** ***

(WHEREUPON, the witness was duly sworn.)

JEREMY COOPERSTOCK, Ph.D.,

called as a witness herein, having been first duly sworn, was examined and testified as follows:

EXAMINATION

BY MR. KNEDEISEN:

Q Good morning, Dr. Cooperstock. My name is Mark Knedeisen. How are you?

A Very well. Good morning, Mr. Knedeisen.

Q We met via Zoom depositions before, correct -- or at least one, correct?

A One I believe.

Q So I know you've been deposed before. If there's ever a time you don't understand my question or cannot hear my question, can you let me know. I'll reask it or rephrase it.

Is that okay?

A Sure.

references.
If I've, you know, discussed it in one of my paragraphs in the declaration, I'm happy to go back and look at that and try to give you a more elaborate comment, but, otherwise, it's not something I've considered.
Q Just come back to Paragraph 30. It's your opinion that a person of ordinary skill in the art could have a bachelor's degree in computer science and two years of experience in wireless communications across short distance or local area networks, correct?
A That's what I wrote, yes.
Q And you have superior skills than that, correct?
A In most of those areas, yes.
Q So can you describe for me how a magnetic element attached to a voice-coil-actuated diaphragm would work as a transducer element?
A So, again, it's not something that I've described in my declaration. I can, you know -- the best I can tell you in terms of generalities

is that that would be interpreted as a speaker or constituent elements of a speaker.

Q Would a POSITA know how a magnetic element attached to voice-coil-actuated diaphragm works as a speaker?

A Quite likely. Somebody who is working in communications technologies would have very likely encountered audio devices as one of the outputs that would be relevant for that.

Q So can you describe for me how it operates?

MS. HARTJES: Objection. Asked and answered.

BY THE WITNESS:

A Yeah. So, again, it's not something that I've gone into in detail, and I haven't described it, I should say, in detail in my declaration. I haven't even used the terminology in my declaration. So if you want me to get into loud speaker design and the elements that are associated with that, we're going into a whole different path of detail.

BY MR. KNEDEISEN:

Q Well, I'd like to hear your explanation of that path of detail. Could you --

A Well, at a -- you know, it's, once again, not something that I've, you know, given thought to. As I was reading the description, as I went through, I said what is relevant here in terms of the claim of the '982 patent. We're talking about an audio transducer or equivalent to the speaker technology.

We, you know, have lots and lots of experience, decades worth, in that sort of technology. That's been around well before the critical date of the '982. And an engineer who is seeking to implement that technology would, you know, have available many references to describe the operation of such an element.

Q Do you see the next type of transducer element Rosener talks about is an electrostatically charged diaphragm? Do you see that? It's Paragraph 30. Right after the voice-coil-actuated diaphragm.

A Yes.
Q Can you describe how an electrostatically charged diaphragm works as a transducer element?
A So much the same as the magnetic element attached to a voice-coil-actuated diaphragm, it's not a term that I have made use of in my declaration. I haven't tried to define it. I haven't considered how a POSITA would define it or what their detailed understanding of it would be other than to know that this is another form of transducer technology that can be used to render audio.
Q Is an electrostatically charged diaphragm different from a magnetic element voice-coil-actuated diaphragm?
A This is, again, something that I would want to dig into the literature in detail to be able to form a response that is accurate.
You know, off the cuff of my head, looking at it right now, I would have to guess at it, but, you know, I would say that this is a form of audio transduction and whether there are similarities or

differences between the terms, that's a matter for looking further into the literature.

Q The end of that sentence in Rosener Paragraph 30 says, "or a combination of one or more of these transducer elements."

Do you see that?

A Yes.

Q How could a speaker have both a magnetic element attached to a voice-coil-actuated diaphragm and an electrostatically charged diaphragm?

MS. HARTJES: Objection. Scope.

BY THE WITNESS:

A Well, again, it's not something that I've considered in my declaration, but certainly we're familiar with loud speakers in our homes that have multiple units within them that are, you know, in a single chassis. So you might have, you know, multiple elements in one unit that was well-known at the time.

BY MR. KNEDEISEN:

Q And by "elements," you mean multiple

speakers?
A Multiple transducer elements.
Q So could one transducer element have both a voice-coil-actuated diaphragm and an electrostatically charged diaphragm?
A This is not something that I've considered. I'd really have to go into details of, you know, speaker design, loud speaker design, earphone design in terms of the actuating element.
My understanding is that the detailed mechanics of the transducer is not the subject of the '982 patent, nor is it, you know, one that is dealt with extensively in the areas of the prior art that I've made reference to in my declaration.
Q Rosener Paragraph 30 also refers to a balanced armature driver.
Do you see that?
A Yes, I do.
Q Could you explain how balanced armature driver works?
A As before, this I understand as another transducer element possibility, and I have not

gone into -- I haven't defined the term or sought to define the term in my declaration or given it any consideration.

Q Is a balanced armature driver different from a voice-coil-actuated diaphragm?

A As before, I'd have to go through the literature to get into the details as to whether the components were different or the same, what -- if there were differences, what those would involve.

This is not something I've gone into in part of my preparation for today.

Q And is a balanced armature driver different from an electrostatically charged diaphragm?

A Again, same answer. I haven't gone into those questions in preparation for today.

Q Turn to Paragraph (inaudible) of your declaration --

A Sorry, which paragraph?

Q Excuse me, what?

A Which paragraph?

Q 39 of your declaration. Which also refers to Paragraph 39 of Rosener, coincidentally.

Do you see Paragraph 39 of your declaration talks about how Rosener provides several methods to synchronize the wireless links?

A Yes.

Q And if we turn to Rosener Paragraph 39, that describes one way of synchronization, correct?

A Yes, it does.

Q I believe it's the second sentence of Paragraph 39 of Rosener says, "One way is to include data buffers in each of the first and second RF receivers 604, 608 and control the buffers so that they maintain a predetermined constant occupancy."

Do you see that?

A Yes.

Q What is occupied in the buffers?

A Well, as Rosener goes on to state, data occupancy. So they are -- they are buffers of data. And that data could consist of audio, it

could consist of other content as well. It's data -- or actually data is plural, so they are data.

Q And do you see the next sentence says, "So, for example, if the data occupancy of a data buffer of one of the first and second RF receivers 604, 608 becomes too low (e.g. due to a fast A/D converter) interpolated or repeated data samples may be inserted into the data buffer to increase the data occupancy of the buffer, thereby forcing the buffer to maintain the intended predetermined data occupancy."

Did I read that correctly?

A You did.

Q So how does a fast A/D converter affect data occupancy of the buffer?

MS. HARTJES: Objection. Vague.

BY THE WITNESS:

A So your question is how does a fast A/D converter affect the occupancy of the buffer?

BY MR. KNEDEISEN:

Q Correct.

A Okay. So this is -- once again, it's not something that I described in my declaration, but my understanding is that an A/D converter that is connected to a buffer will take samples out of that buffer...

Right. Yeah, so it's taking samples out of the -- out of the buffer of the received data and passing it on to the next stage in the circuit. So if that A/D converter is running fast, it's going to take samples out of that buffer at a rate that is higher than intended.

Q Does the buffer store data samples?

A If we're talking about a data buffer, then, yes, the buffer would store data.

Q Would it store data samples?

A So we're getting into terminology now of what a sample and what Rosener is referring to as a sample would represent. And this is where terminology can get pretty muddied, especially dealing with the audio world.

Some practitioners will talk about samples, you know, purely as a result of the

sampling process. So looking at a waveform and sampling it at a particular frequency with a particular bitrate, whether the sample is analog or digital.

So I see that Rosener does talk about data samples, but they -- again, the interpretation of that phrase or that term is subject of, you know, considerable debate among practitioners, is this, you know, a sample -- is this a sample in the context.

So I'm hesitant to weigh in on giving you a succinct, you know, this is what is stored, this is a data sample or, yes, it would be. But we will say that, you know, based on what Rosener's describing, it is a buffer that contains data.

Q Do you see where the line -- the sentence I just read in Rosener talks about how interpolated or repeated data samples may be inserted into the data buffer to increase the data occupancy of the buffer?

Do you see that?

A Yes.

Q And how would a POSITA interpret the term "data samples" in that sentence?

A So, once again, the term -- the terminology of "data samples" is one that a POSITA could interpret in many different ways.

And, you know, in this context, you know, I'm looking at it as putting an additional element of data. But whether it's something that all practitioners or POSITAs at the time would agree is a sample is one that we'd have to have, Okay, this is what we're going to consider a sample definition for. And I don't know if Rosener provided one in the '489 patent.

Q Well, what do you understand the statement in Rosener to mean?

A I'm looking at it at a general level rather than trying to interpret the word "sample." And I'm understanding this as whether it's...

Yeah, so it's the same buffer. So whatever the data element are that are contained in that buffer -- we'll call those element samples as per Rosener -- Rosener is suggesting that to

compensate for a fast A/D converter, one of those elements or more of them would be repeated or interpolated and inserted back into the same storage area that's called the data buffer.

Q So is a buffer a data storage area?

A Well, once again, definitions that I haven't weighed in on in my declaration, but a buffer is a place where we hold information, where information or data are held.

Q And how would the buffer described in Rosener be implemented?

MS. HARTJES: Objection. Vague.

BY THE WITNESS:

A So there are many ways in which a data buffer can be implemented. There are different kinds of semiconductor technologies. There are different kind of organizational structures. I think that's really an implementation decision for the designer.

BY MR. KNEDEISEN:

Q Does the buffers described in Rosener just store analog data?

A So reading Rosener -- and this is, again, not something that I've weighed in on in my declaration. But my understanding is that if there's an A/D converter that is consuming content from the buffer, that means the buffer is holding analog information or analog data.

MS. HARTJES: Counsel, we've been going a little over an hour. Is there a good stopping point anywhere?

MR. KNEDEISEN: We can take a break now. Or, Dr. Cooperstock, do you want to --

THE WITNESS: Sure. Yeah, a short break would be appropriate.

MR. KNEDEISEN: What do you want to do -- well, we should go off the record.

MS. REPORTER: Sure. Off the record.

(WHEREUPON, a recess was had.)

THE TECHNICIAN: We are back on the record.

BY MR. KNEDEISEN:

Q Dr. Cooperstock, turning again to Paragraph 39 of Rosener, we were talking about the

Paragraph 40 of Rosener, correct?
A Yeah, so Paragraph 40 deals with the second approach, another way.
Q And you refer to Paragraph 40 in your declaration at Paragraph 39, correct?
A Yes.
Q And is it correct that the way in Paragraph 40 to deal with the -- to compensate for the differential latencies is to embed a data sample clock used by the RF transmitters in the RF carrier signals used to carry the first and second data streams over the first and second wireless links?
A That is correct.
Q And Paragraph 40 refers to analog sub-carrier signals, correct?
A Yes.
Q What is an analog sub-carrier signal?
A So, yeah, that's, again, terminology that I haven't included in my declaration and haven't considered. Was not getting into details of the, sort of, fundamentals of RF communication. These

were well-known to POSITAs at the time.

Q And how would a POSITA understand the term "analog sub-carrier signal"?

A So, again, this is not something that I, you know, felt the need to consider as to the terminology of these detailed RF communication parameters.

It's something, in terms of giving you what an understanding of a POSITA would be of that term at the time, I would go back to literature that was available.

Q I think you just said it would have been well-known to a POSITA, correct?

A Yes.

Q But you can't tell me what would have been well-known to the POSITA?

A Well, there's a certain number of years that have elapsed since then and terminologies, and understanding of the terms changed over time. So I'd want to -- if you wanted me to give you a definition as to what a POSITA would have known at the time or of how they would have understood the

sub-carrier terminology at the time, I'd want to go back and make sure that -- refreshing my memory in terms of what the -- the sources, literature, would have defined those terms as.

Q That sentence that refers to analog sub-carrier signal says that this technique may be accomplished by modulating each of the RF carrier signals associated with the first and second RF transmitters 610, 614 with analog sub-carrier signals.

How do you -- how does one modulate an RF carrier signal with an analog sub-carrier signal?

A So, once again, these are areas that I've not gone into in my report. I wasn't asked to consider those questions of RF basics.

And in order to give you that answer, I'd want to take the time to go back to references, possibly textbooks that were being used at the time frame to get into details of RF communication.

Q All right. Why don't we turn to Paragraph 41 of Rosener.

Does Paragraph 41 describe another way of compensating for the differential latencies between the first and second data streams?
A Yes, it does.
Q And what's the technique described in Rosener's Paragraph 41?
A It's describing the use of an exclusive OR operation or a pseudorandom noise sequence that is inserted into the digital modulation of the carrier signals and --
Q So --
A -- TIA/IS-95 radio standard.
Q Are you familiar with the TIA/IS-95 radio standard?
A No, I'm not.
Q How would using an exclusive or pseudorandom noise sequence compensate for differential latencies?
A So, once again, this is not an area that I've dealt with in my declaration or not something I was asked to consider for my report in terms of the detailed algorithms involved in inserting --

or exclusive ORing or inserting random noise or pseudorandom noise into the digital modulation.

Q And what does exclusive OR mean?

A Exclusive OR is if you have two bits, for example, an X and a Y, if both of them are the same value, like, if they're both zero or they're both 1, then the exclusive OR will return a zero.

If they're different, one is zero, one is 1, then the exclusive OR operation will return a 1.

Q All right. Let's turn to Paragraph 42 of Rosener.

Does Paragraph 42 of Rosener describe yet another technique for compensating for the differential latencies?

A It does.

Q And how does the technique in Paragraph 42 operate?

A As described here, it's adjusting the clock signals used by the A/D converters of the first and second RF receivers.

Q And, again, this talks about if one of the

buffers is too low, the A/D clock is slowed down.
Do you see that?
A Correct.
Q And, conversely, if that A/D buffer is too high, the A/D clock sped up, correct?
A That is correct.
Q So let's go to the first one. If A/D buffers is too low, why would speeding up the A/D clock compensate for the differential latencies?
A Sorry, could you repeat your question.
Q If the A/D buffer occupancy was too low, how would slowing the A/D clock compensate for the differential latencies?
A Okay. Sorry. I thought you said sped up. So --
Q I might have said sped up.
A So if the data buffer is low...
Yeah, so if your buffer is low, then the rate at which it's being depleted can be adjusted by changing the clock on the A/D converter, which is taking samples, taking data out of the buffer, and thereby change the rate at which it's being

depleted.
Q All right. Could you turn to Figure 9 of Rosener.
MR. KNEDEISEN: Could the technician -- is there a way to rotate that on the screen?
THE WITNESS: I've got it on mine rotated.
MR. KNEDEISEN: All right.
THE TECHNICIAN: One second.
BY MR. KNEDEISEN:
Q Dr. Cooperstock, do you see the data sink in upper right, element 918?
A Yes.
Q What is the data sink 918 in Rosener?
A So a sink is, in the terminology here, something where data is sent to. And in this case, it's the last stage of the circuit in Figure 9 in terms of the pathway. In the context of a listening device, it's likely to be an audio transducer of some form.
Q Your answer referred to the pathway and the transducer being the last stage. Can you describe the other stages of the pathway in

Figure 9.
A Well, you have -- let me get back to it here on my screen.
So you have an antenna that connects to a duplexer. It goes in through an LNA --
Q Can I interrupt? What's an LNA?
A A low-noise amplifier.
Q Okay.
A And from there into a down-converter, into an A/D converter, into a baseband processor, into signal conditioning circuitry, and then finally to the data sink.
Q Why don't we go through the components you just talked about.
What does the down-converter do?
A So just referring to the language of Rosener who describes it as providing down-converted analog baseband signals.
Q And what's a baseband signal?
A So this, again, not something that I was asked to consider in my report or my declaration, so if I give you a definition here, it's something

Q And Hankey discloses flexible circuit boards, correct?

A Yes, flexible circuit board.

Q And what would the flexible circuit board be made of, what material?

And I'll qualify, I don't think Hankey says and I don't think your report says. I'm asking --

A I was just curious to see if I could find a description within Hankey as to what -- what the invention -- what Hankey's invention proposed as being the material. But I certainly didn't consider that in my report.

Q Unless I missed it, I don't see where it says. But in your opinion as an expert, what do you think it would be fabricated from?

A Yeah, I think that's -- in terms of the material of what sort of material is best suited for a flexible circuit board, that's getting into more of the kind of materials science, which I think is going outside my expertise.

So I'm not willing to hazard a guess here.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00381
U.S. PATENT NO. 10,491,982

DECLARATION OF JOSEPH C. MCALEXANDER III

September 28, 2021

TABLE OF CONTENTS

1. I, Joseph C. McAlexander III, declare as follows:

2. I have been retained by counsel for Koss Corp. ("Koss") as a technical expert in connection with the *inter partes* review ("IPR") proceeding identified above for U.S. Patent 10,491,982 (the "'982 Patent"). I submit this declaration in support of Koss's response to the petition.

I. BACKGROUND AND QUALIFICATIONS

3. I have a Bachelor of Science in Electrical Engineering from North Carolina State University and have studied neural science at the University of Texas Graduate School of Biomedical Science.

4. Upon completion of my electrical engineering degree in 1969, I was commissioned as an officer in the U.S. Army. For 2 years, I managed the air defense operation for the New England area, which included radar and secure communication channels to aircraft, missile batteries, and U.S. Command. I then commanded a signal battalion in South Korea for 1 year, designing and orchestrating at the division level the first of its kind communication power grid mapping study using AM and FM transmission/reception, among others, and utilizing crypto security transmission/reception methods.

5. I am a Registered Professional Engineer in the state of Texas (Reg. No. 79,454) and am a recognized inventor on thirty-one U.S. patents. I have forty-nine years of professional experience, during which I designed and analyzed a

variety of microcircuits, semiconductors, and control systems, amongst other technologies for Texas Instruments, Inc. and EPI Technologies, Inc. Specifically, I have designed Dynamic Random Access Memories ("DRAMs"), Static Random Access Memories ("SRAMs"), Charged Coupled Devices ("CCDs"), Shift Registers ("SRs"), and a variety of functional circuits, including input/output buffers for addresses and data transmission, decoders, clocks, sense amplifiers, fault tolerant parallel-to-serial data paths for video applications, level shifters, converters, pumps, logic devices, wireless communication systems, and microelectromechanical systems ("MEMs"). I possess significant expertise in operations and manufacturing associated with these technologies, including a sophisticated knowledge of quality control, testing, reliability, and failure analyses.

6. I have conducted high level instruction to design and process engineers and managers at Texas Instruments, among others, in Solid State Device Physics, Semiconductor Processing, Circuit Design Techniques, and Statistical Quality Control Methods. I have also instructed corporate audiences in Effectiveness Training, Japanese Manufacturing Techniques, and problem recognition and solution methods and tools.

7. As part of licensing of my IP circa 2002 – 2004, I negotiated and executed a number of licensing and design programs to provide GPS tracking and transmission of information wirelessly, using paging and CDMA. The

technologies included partnerships for skier tracking with Snowtrax, offender tracking with Stellar Technology Enterprises, pet tracking with The Procter & Gamble Company, journalist tracking with CNN, asset tracking with TrackDaddy, and family tracking with Disney, to name a few. I also advised a startup between 2013 and 2018 in peer-to-peer encrypted cellular communication.

8. I have provided consultancy services associated with the aforementioned technologies. My consulting career began with Cochran Consulting, Inc. in 1991. Currently, I am the President of McAlexander Sound, Inc. and the Managing Director of McAlexander Sound Pte Ltd., where I offer such consultancy services and serve as a Technical Advisor for highly-specialized matters. I provide expert witness services for the protection of intellectual property. As an expert witness, I have investigated processes and designs associated with personal computers, peripheral computers, software, and wireless communications systems, including telephones, microprocessors, controllers, memories, programmable logic devices, and other consumer electronics.

9. As part of my work with McAlexander Sound, I have gained intimate experience with sound and lighting systems. I am very familiar with how acoustic speakers operate and the design issues associated with sound systems.

10. A copy of my curriculum vitae is attached as Appendix A hereto.

using an access point." *Id.*, 3:11-14. The "ad hoc" communication link could use Bluetooth, for example. *Id.*, 4:63-67. The headphones may comprise one or more in-ear, earphone elements. *Id.*, 3:1-6.

20. I understand that, according to Dr. Cooperstock, as of April 7, 2008, a person of ordinary skill in the art ("POSITA") to which the '982 Patent pertains "would have had at least a Bachelor's Degree in an academic area emphasizing electrical engineering, computer science, or a similar discipline, and at least two years of experience in wireless communications across short distance or local area networks," with the proviso that "[s]uperior education could compensate for a deficiency in work experience, and vice-versa." APPLE-1003, ¶30; KOSS-2037, 29:14-30:8. The proposed standard and skill level seem reasonable given the context of the '982 Patent; and I adopt the proposed standard for purposes of my opinions herein. A person with these skills and experience would not necessarily have skills or knowledge specific to designing the acoustic transducer for a wireless earphone, fitting all of the components into a small form factor earphone, or suitably powering a wireless earphone given the safety and size constraints. Also, experience with short distance wireless communications and LANs would not necessarily translate to experience involving acoustics, wireless headphone or wireless speakers.

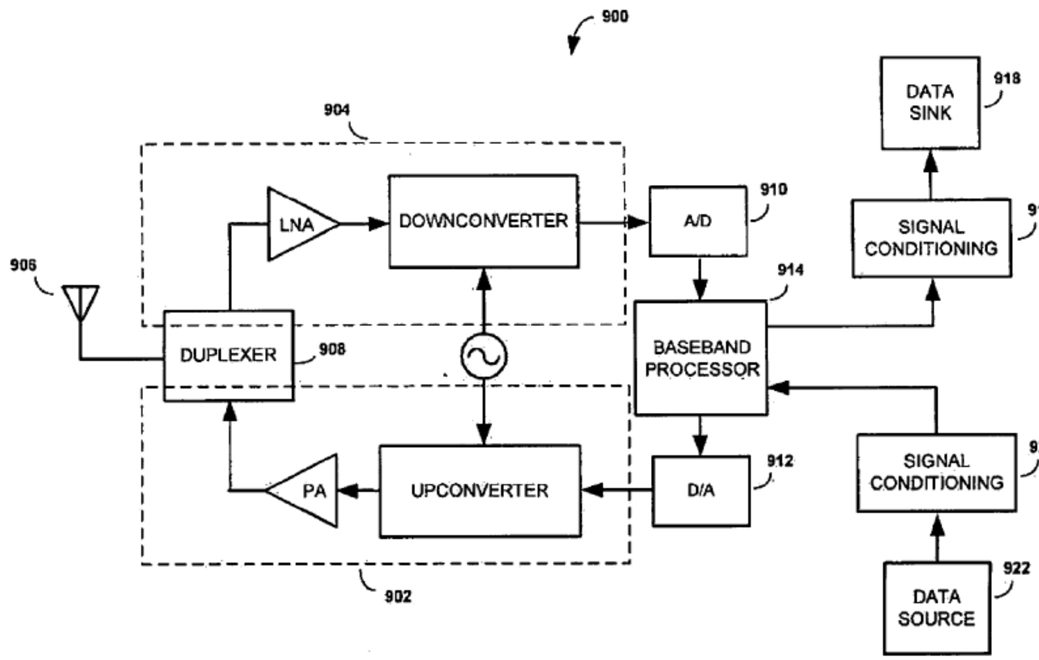


FIGURE 9

B. Hankey

45. Hankey discloses "headsets for communicating with an electronic device." APPLE-1005, ¶[0009]. More precisely, Hankey discloses a single-earpiece headset that includes a flexible circuit board that can "fold upon itself or bend," which allows the circuit board to "fit in smaller or less traditionally-shaped earbuds." APPLE-1005, ¶[0130]. A headset 500 with an earbud 520 and a primary housing 510 that can accommodate a receiver 524, processing circuitry 526, and a microphone 514 via flexible circuit boards 522, 512 is illustrated in Figure 5, reproduced below. *Id.*

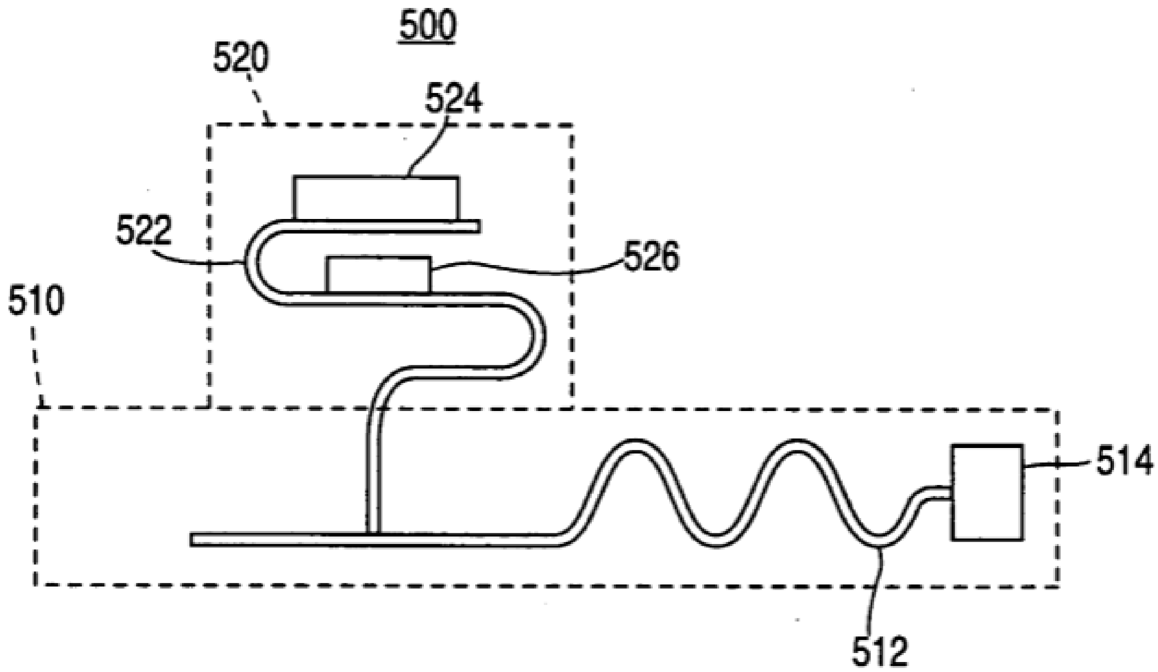


FIG. 5

VII. CLAIM 1 WOULD NOT HAVE BEEN OBVIOUS TO A POSITA

A. A POSITA Would Not Have Been Technically Qualified to Modify Rosener in View of Hankey (and Dyer)

46. I disagree with Dr. Cooperstock's assertion that a POSITA with a bachelor's degree in computer science and two years of experience with local area networks would have been capable of modifying Rosener in view of Hankey to arrive at the subject matter of claim 1 as of, what Dr. Cooperstock refers to as, the "Critical Date." KOSS-2037, 37:7-16. Dr. Cooperstock uses April 7, 2008 as the "Critical Date." APPLE-1003, ¶13. I use the term "Critical Date" below in the same way, *e.g.*, April 7, 2008.

47. The proposed modification would require superior skills in audio electronics far beyond those of a POSITA, who according to Dr. Cooperstock can have merely a bachelor's degree in computer science and two years of experience with local area networks ("LANs"). APPLE-1003, ¶30; KOSS-2037, 36. However, it is my technical opinion that the proposed modification (*e.g.*, the Rosener-Hankey combination and/or Rosener-Hankey-Dyer combination) would require detailed knowledge of and experience with the components utilized by the wireless headsets disclosed in Rosener and Hankey, beyond the capabilities of a POSITA. This includes a specific knowledge of the individual transducer elements, signal processing, and data buffering disclosed by Rosener and Hankey, as well as a specific knowledge as to how such components are integrated into small form factor wireless headphones that provide an acceptable sound quality and a comfortable fit within the user's ear.

48. For example, Dr. Cooperstock, who I understand has relevant skills for the '982 Patent superior to those of a POSITA with a bachelor's degree in computer science and two year experience with LANs, could not identify a suitable material for the flexible electrical connector in the proposed combination. KOSS-2037, 67:1-68:4. However, before a POSITA merely crammed the components of Rosener into the form factor of Hankey, a POSITA would have to make considerations regarding circuit board construction to ensure the mechanical

integrity of the assemblies, preservation of the electrical components, and electromagnetic interference (EMI) mitigation. For, example, the flexible circuit boards would need to be flexible enough to be manipulated to fit into the small form factor wireless earphone, yet rugged and sturdy enough to withstand the wear and tear of consumer use. Also, a POSITA would have to design the earphones so that the EMI from the components do not unacceptably degrade or interfere with the wireless signals received by the wireless earphone. In my opinion, a POSITA, especially without experience in designing wireless earphones, would have struggled to appropriately design the flexible circuit board(s) and the arrangements of the components thereon in view of these multiple, competing design considerations. As but one example, Dr. Cooperstock could not even identify a suitable material for the flexible circuit board, admitting that "material science…is going outside my expertise." KOSS-2037, 67:17-21.

49. Also, Dr. Cooperstock, with his superior skills and knowledge to that of a POSITA, exhibited a failure to accurately understand the technical disclosure of Rosener and Hankey that are critical to designing a wireless earphone and making the combinations proposed by Petitioner. Excerpts from the deposition of Dr. Cooperstock that exhibit his confusion regarding the components of Rosener and Hankey, many of which are critical to the construction of an operational set of wireless earphones, are addressed below. I believe that Dr. Cooperstock's

confusion and, at a minimum, the reasonable differences between the technical opinions of Dr. Cooperstock and me, establishes that a POSITA, with far less experience than the two of us, could not make the combinations proposed by Petitioner with a reasonable expectation of success.

B. A POSITA Would Not Understand the Transducers of Rosener and Thus, Could Not Modify Them in View of Hankey

50. To design and construct operative wireless earphones, the designer would need to select the appropriate transducer design given the sound quality and earphone form factor considerations. A POSITA, with a bachelor's degree in computer science and two years of experience with LANs, would not understand how the transducers disclosed by Rosener work and thus, would not be qualified to select and design the transducer for the Rosener-Hankey combination (and Rosener-Hankey-Dyer combination) in light of the competing design considerations, including sound quality and fit (*e.g.*, fitting a quality transducer into the compact form factor earphones of Rosener and Hankey).

51. Rosener explains that the speaker could be "a magnetic element attached to a voice-coil-actuated diaphragm, an electrostatically charged diaphragm, a balanced armature driver, or a combination of one or more of these transducer elements." *Id.*

52. Dr. Cooperstock was hesitant (or unable) to provide details regarding

the functionality and implementation of these transducers, which are obviously critical to the effective operation of a wireless headset. KOSS-2037, 37-41. In view of Dr. Cooperstock's hesitance to explain the operation and integration of these transducers, a POSITA, with merely a bachelor's degree in computer science, two years of experience with LANs, and no experience designing wireless earphones, would, in my opinion, not have a reasonable expectation of success in integrating the transducers of Rosener to fit within the compact form factor of Hankey. Such a POSITA would likely struggle with which type of transducer to select for the sound quality that is desired for the wireless earphone; how to fit the selected transducer into the small form factor wireless earphone; and how to deliver suitably the sound from the transducer to a port of the earphone. Indeed, as I described above, different transducer types have different properties and performance levels. Selecting the appropriate transducer type, and then designing the rest of the earphone to accommodate that transducer type (*e.g.*, the size and air flow requirements) would be beyond the skill of a POSITA that did not have experience designing earphones, such as a POSITA with a computer science degree and experience with LANs.

C. A POSITA Would Not Understand the Analog-to-Digital Converter and Buffer of Rosener and Thus, Could Not Modify Them in View of Hankey

53. A POSITA, with a bachelor's degree in computer science and two

years of experience with local area networks, would not, in my opinion, understand, or at least have severe difficulty understanding, how Rosener's analog-to-digital ("A/D") converter and data buffer work and thus, would not be qualified to implement the A/D converter and data buffer of Rosener to fit into the compact form factor of Hankey.

54. According to Dr. Cooperstock, Rosener's A/D converter "take[s] samples out of" the data buffer and "consumes" the data samples in the data buffer. KOSS-2037, 46, 50, 60. I interpret Rosener differently. In my opinion, an A/D converter is an electronic device whose function is to convert analog signals (*e.g.*, the received RF signal in Rosener after the processing in Rosener's Fig. 8A or Fig. 8B receivers) into sample values of the analog signals at discrete times, with the sample values being "digitized," *e.g.*, represented (and stored) as binary data (1s and 0s). The digitized samples would be stored in Rosener's data buffers, described above. In other words, an A/D converter, by its very nature, converts an analog signal to digital values. It only makes sense, therefore, that the A/D converter of Rosener would convert an input analog signal into digital data that can be subsequently stored in the data buffer. Also, a POSITA would understand the term "data buffer" in Rosener to mean physical memory that stores digital data, often temporarily.

55. My technical interpretation of an A/D converter is consistent with the

teachings of Rosener. Rosener explains that if an A/D converter is too slow, data sent by the corresponding transmitter 610, 614 will be lost at the sending end because the data has no place to go. APPLE-1004, ¶[0038]. On the other hand, the A/D converter will stall if it operates too fast, since it will run out of data faster than data are provided to it. *Id.* That is why, in one of Rosener's differential latency compensation techniques, additional samples (*e.g.*, interpolated or repeated one) are added to the data buffer if the A/D converter is too fast and the occupancy of the data buffer gets too low. And, conversely, data samples are removed from the data buffer if the A/D converter is too slow such that there are too many samples in the data buffer.

56. I see nothing in Rosener that indicates that the A/D converter takes digitized samples out of the data buffer, as asserted by Dr. Cooperstock. My technical interpretation of the A/D converter of Rosener is informed by my many years of audio engineering experience. Obviously, my opinion differs from that of Dr. Cooperstock, who has a PhD in computer and electrical engineering and twenty five years of professional experience. At a minimum, our difference in technical opinion in this regard only underscores the point that a POSITA—with a bachelor's degree in computer science and two years of experience with local area networks—would not be able to combine or modify reasonably Rosener and Hankey to achieve the headphones of claim 1, as suggested by Dr. Cooperstock. In

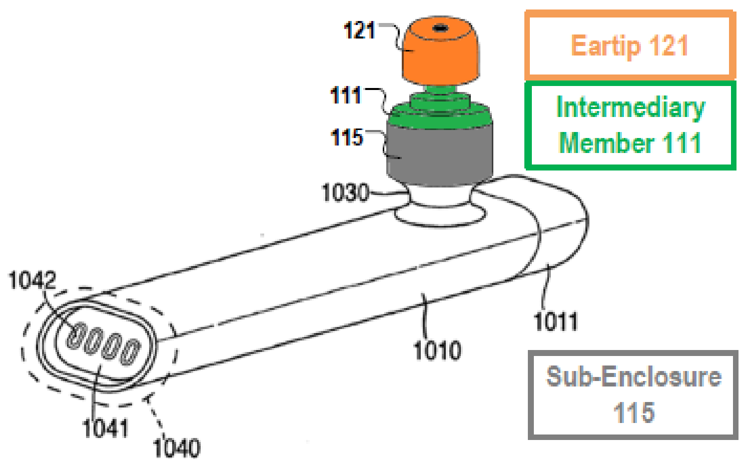
my opinion, the proposed combination would only be achievable by a POSITA via a significant amount of technically complex experimentation, which would be exacerbated by a POSITA's lack of experience. In other words, the POSITA would not have a reasonable expectation of success making the combination due to complex technical issues that are beyond their skill level, especially a POSITA with a computer science degree and experience with LANs, but no experience designing wireless earphones.

D. Petitioner's Illustration of Rosener-Hankey-Dyer Evidences the Acoustic and Mechanical Infeasibility of the Asserted Combinations

57. The proposed combination of Rosener and Hankey would also require an intimate knowledge of the design and construction of wireless earphones. Specifically, the designer would need to select an appropriate transducer design given the sound quality and earphone form factor considerations. A POSITA, as defined by Dr. Cooperstock, would not possess the knowledge or experience required to achieve a desirable sound quality and form factor and, therefore, would have no reasonable expectation of success making wireless earphones with a transducer in the "top part," as proposed by Petitioner. Pet. at 27.

58. Nothing in the disclosure of Dyer would compensate for a POSITA's lack of technical expertise. In fact, the improbability of the proposed combination is evidenced by Petitioner's illustration of the hypothetical Rosener-Hankey-Dyer

canalphone, reproduced below. *See e.g.*, Pet. at 31.



59. I agree with Mr. Blair, that the "body portion" in the Rosener-Hankey-Dyer canalphone would not fit in a user's ear. KOSS-2039, 10. Mr. Blair provided more details in his declaration but, in summation, any friction between eartip 121 and a user's ear would be easily overcome by the weight of the intermediary member 111 and sub-enclosure 115, as the center of mass of the proposed device would create a moment arm that would pull the earphone out of a user's ear. A POSITA would likely understand that the combination of Rosener-Hankey-Dyer, as proposed by Petitioner, would not be mechanically feasible and thus, a POSITA would not be motivated to modify Rosener in view of Hankey and Dyer to make the combination proposed in the Petition.

60. Furthermore, the combination of Rosener-Hankey-Dyer, as proposed by Petitioner, evidences a lack of understanding of the acoustical engineering

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

CASE: IPR2021-00381
U.S. PATENT NO. 10,491,982

DECLARATION OF NICHOLAS S. BLAIR

I, Nicholas S. Blair, declare as follows:

I. BACKGROUND

1. I am the Director of Product for Koss Corporation ("Koss"). I have been employed by Koss since 2013. My prior position at Koss was Senior Industrial Designer.

2. Prior to my employment at Koss, I worked at:

- RedFusion Studios ("RedFusion") from 2009 to 2013;
- Brooks Stevens Inc. from 2006 to 2010;
- Discovery Channel's Smash Lab from 2007 to 2008;
- Beyond Design, Inc. in 2006;
- Brunswick Corporation in 2005 to 2006; and
- Design Concepts from 2003 to 2005.

3. I received a Bachelor's in Fine Arts from the Milwaukee Institute of Art & Design in 2001, and I studied architecture at the University of Wisconsin-Milwaukee.

4. My professional career has focused on designing products for consumers. Through my employment at both Koss and RedFusion, a significant focus of my work has been on the design of earphones. I am familiar with the design concepts and issues related to all types of earphones, including earbuds, in-ear, on-ear, and over-ear earphones. I have devoted a large portion of my professional career

would seek to pivot the "body portion" out of the user's ear. Any connection between the in-ear portion of the canalphone and the user's ear would be tested by this torque. Moreover, the extended moment arm between the neck 1030 and the sound delivery member 111/eartip 121 would exasperate the effect of any force—in addition to the downwardly-extending force corresponding to the weight of the primary housing—applied to the primary housing 1010. In short, Cooperstock's Rosener-Hankey-Dyer canalphone would be easily dislodged from a user's ear during normal, everyday use.

19. The outer earphone enclosure 115 in Dyer is large enough to enclose and protect Dyer's low-frequency armature driver 101 and high-frequency armature driver 103, which are the acoustic transducers for Dyer's earphone 100. An ill-fitting canalphone prone to acoustic leakage, such as Cooperstock's Rosener-Hankey-Dyer canalphone, would require a larger acoustic transducer than well-fitting earphones for equivalent sound quality. A relatively larger acoustic transducer explains the bulbous geometry and length of the outer earphone enclosure 115 even as applied in Cooperstock's Rosener-Hankey-Dyer canalphone.

20. This is why, in my opinion, Cooperstock's Rosener-Hankey-Dyer canalphone would not stay in a user's ear. The canalphone does not include an adequate securing mechanism, and the "body portion" thereof forms an extended cantilevered arm between the in-ear portion of the canalphone and the primary

housing 1010, which would generate a significant torque at the in-ear portion from the offset weight of the primary housing. Such torque would cause user discomfort as the canalphone is rotated upward away from the lower surface of the concha and would likely dislodge the canalphone from the user's ear. In my years of experience, I have never seen a canalphone like Cooperstock's Rosener-Hankey-Dyer canalphone, which lacks an adequate securing mechanism and has an elongated arm between the primary housing and the in-ear portion. Cooperstock's canalphone is also not aesthetically pleasing because the primary housing 1010 would be positioned awkwardly far from the user's ear.

III. CONCLUDING REMARKS

21. I am not being paid specifically for making this declaration, although I am paid by Koss for my employment. I have no direct interest in the outcome of any litigation involving the '982 Patent, although I own stock in Koss.

22. In signing this declaration, I recognize that this Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

23. I am a U.S. citizen, a resident of the United States, over 18 years of age,